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I.

THE ORIGIN OF THE PLANETS.

BY

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WITH FOUR PLATES.

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THE ORIGIN OF THE PLANETS.

1. If the several members of our solar system be considered with regard to their distance from the Sun, a very curious relation will be found to exist between them. It is this:

> The major axes of their orbits are such that the mean motion of each body is an almost exact multiple of its neighbor's in one of the three proportions $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$, and in the case of Venus and the Earth $\frac{3}{5}$; these ratios corresponding to closely adjacent places in space.

Investigation into the cause of such commensurability reveals an important law:

Each planet has formed the next in order, of necessity at exactly one of these commensurable points, at the same time displacing it slightly sunward. In other words, the positions of the planets are not haphazard but have been determined *seriatim* each by its predecessor; thus showing that the solar system is an articulated whole, an inorganic organism, which not only evolved but evolved in a definite order, the steps of which celestial mechanics enable us to retrace.

This I shall now proceed to show.

2. The orbital elements of any planet are:

m = the mass,
a = the major axis,
n = the mean motion,
e = the excentricity,
ϖ = the longitude of the perihelion,
I = the inclination to the ecliptic,
Ω = the ascending node,
ϵ = the mean longitude at the epoch.

Unaccented these will refer to the inner planet, accented to the outer.

M = the mass of the Sun, which will be taken as unity.

$$M + m = \mu.$$

In elliptic motion $n^2a^3 = \mathrm{f}\mu$, where f is the constant of gravitation.

The potential of the perturbing force, called the perturbing function, is for the outer planet on the inner

$$R = \mathrm{f}\frac{m}{\rho} - \mathrm{f}\frac{m'r\sigma}{r'^2},$$

and for the inner on the outer

$$R = \mathrm{f}\frac{m}{\rho} - \mathrm{f}\frac{mr'\sigma}{r^2}.$$

To find the motion from this expression recourse has to be had to series, first in powers of the masses and then in those of the excentricities and inclinations, which, because the masses of the planets are very small compared with the Sun and the excentricities and inclinations for the principal planets are also small, prove rapidly convergent, if the time considered be not too long. Expressed in ascending powers of the latter, the first term $\mathrm{f}\frac{m'}{\rho}$ gives

$$\begin{aligned} R_1 = {} & \Sigma\left[\tfrac{1}{2}A^{(i)} - \tfrac{1}{2}\eta^2 B^{(i-1)} + \frac{e^2+e'^2}{8}\left(-4i^2A^{(i)} + 2A_1^{(i)} + 2A_2^{(i)}\right)\right]\cos i\,(l'-\lambda) \\ & + \tfrac{1}{2}e\Sigma\left[-2iA^{(i)} - A_1^{(i)}\right]\cos\left[il' - (i-1)\lambda - \omega\right] \\ & + \tfrac{1}{2}e'\Sigma\left[(2i+1)A^{(i)} + A_1^{(i)}\right]\cos\left[(i+1)l' - i\lambda - \varpi'\right] \\ & + \tfrac{1}{8}e^2\Sigma\left[(4i^2-5i)A^{(i)} + (4i-2)A_1^{(i)} + 2A_2^{(i)}\right]\cos\left[il' - (i-2)\lambda - 2\omega\right], \text{ etc., etc.} \end{aligned}$$

In which

$$A^{(i)} = \frac{f_{\frac{1}{2}}^{(i)}(\alpha)}{a'}, \qquad B^{(i)} = \frac{f_{\frac{3}{2}}^{(i)}(\alpha)}{a'}, \quad \text{and} \quad A_n^{(i)} = \frac{a^n}{1,2\ldots n}\frac{d^nA^{(i)}}{da^n}, \qquad B_n^{(i)} = \frac{a^n}{1,2\ldots n}\frac{d^nB^{(i)}}{da^n},$$

where

$$\alpha = \frac{a}{a'}.$$

The second part $\frac{-\mathrm{f}m'r\sigma}{r'^2}$, for an outer planet on an inner, merely adds to R in $A^{(1)}$ and $A_1^{(1)}$ $-\frac{a}{a'^2}$; in $B^{(0)}$ and $B_1^{(0)}$, $-\frac{2a}{a'^2}$; while $-\mathrm{f}\frac{mr'\sigma}{r^2}$, for an inner on an outer, adds in $A^{(1)}$, $-\frac{a'}{a^2}$, in $A_n^{(1)}$, $(-1)^{n+1}(n+1)\frac{a'}{a^2}$, in $B^{(0)}$, $-\frac{2a'}{a^2}$, and in $B_n^{(0)}$, $(-1)^{n+1}2(n+1)\frac{a'}{a^2}$.

As we shall treat the planets as lying in one plane, consequently

$\lambda = l + \tau' - \tau$ becomes $l = nt + \epsilon$, the mean longitude; and $\omega = \varpi + \tau' - \tau$,

where τ and τ' are the angular distances to the intersection of the two orbits reckoned first along the reference plane and thence along the orbits, becomes ϖ.

3. Analytic processes give us the changes in the elements with regard to the time in well-known equations, of which those we shall have occasion to use are, for m' on m:

$$\frac{da}{dt} = \frac{2m'na^2}{\mu}\frac{dR_1}{d\epsilon},$$

$$\frac{dn}{dt} = -\frac{3m'n^2a}{\mu}\frac{dR_1}{d\epsilon},$$

$$\frac{d\epsilon}{dt} = -\frac{2m'na^2}{\mu}\frac{dR_1}{da} + \frac{m'na\sqrt{1-e^2}}{\mu e}(1-\sqrt{1-e^2})\frac{dR_1}{de} + \frac{m'na\tan\frac{i}{2}}{\mu\sqrt{1-e^2}}\frac{dR_1}{di}$$

Inspection of R will show that to the first order in the masses neither a nor n have any secular terms, terms, that is, increasing with the time; since $\frac{da}{dt}$ and $\frac{dn}{dt}$ both depend upon $\frac{dR}{d\epsilon}$ which enters only into the periodic ones. Not so $\frac{d\epsilon}{dt}$. For $\frac{d\epsilon}{dt}$ has constant terms introduced by $\frac{dR}{da}$, $\frac{dR}{de}$ and $\frac{dR}{di}$. When, therefore, it is integrated, giving $\delta\epsilon$, a term st is produced, which combines with nt to change permanently the mean motion. Analogically we get $\delta\epsilon'$, and $\delta\epsilon$ and $\delta\epsilon'$ are always of opposite signs.

Thus for Uranus and Neptune we find, taking the important term only:

$$\frac{d\epsilon}{dt} = -\frac{m'}{\mu}n\alpha f(\alpha) \qquad \text{and} \qquad \frac{d\epsilon'}{dt} = +\frac{m}{\mu'}n'f'(\alpha),$$

whence

$$\delta\epsilon = -.467\frac{m'}{\mu}nt \qquad \text{and} \qquad \delta\epsilon' = +3.001\frac{m}{\mu'}n't.$$

The geometric explanation of this is that the outer planet acting in opposition to the sun, amounts to diminishing the sun's mass, thus decreasing the mean motion at the same distance. The inner planet's action is equivalent to an increase of the Sun's mass which increases the mean motion. Thus a body already formed tends to draw surrounding matter to itself by making that matter's mean motion more nearly synchronous with its own.

4. But another factor, less conspicuous, is even more concerned in such attraction. As regards the periodic terms R may be written

$$R = \sum fm'\frac{f(\alpha)}{a'}\left(\frac{e}{2}\right)^h\left(\frac{e'}{2}\right)^{h'}\cos\left\{(i'n'-in)t + i'\epsilon' - i\epsilon - k\varpi - k'\varpi'\right\}$$

in which by the mode of development:

i' and i are always whole numbers;

$h + h' +$ an even number, zero included, $= i' - i$;

$h = k +$ an even number, zero included;

and $h' = k' +$ an even number, zero included,

Consider any one of these terms in

$$\frac{da}{dt} = \frac{2nm'a^2}{\mu}\frac{dR_1}{d\epsilon}$$

$$\frac{dR_1}{d\epsilon} = \frac{f(\alpha)}{a'}\left(\frac{e}{2}\right)^h\left(\frac{e'}{2}\right)^{h'} i \cdot \sin\{(i'n' - in)\,t + i'\epsilon' - i\epsilon - k\varpi - k'\varpi'\},$$

which, calling the angle θ, gives

$$\frac{da}{dt} = +2\frac{m'}{\mu}na\alpha f(\alpha)\left(\frac{e}{2}\right)^h\left(\frac{e'}{2}\right)^{h'} i \cdot \sin\theta,$$

and integrating,

$$\delta a = -2\frac{m'}{\mu}na\alpha f(\alpha)\left(\frac{e}{2}\right)^h\left(\frac{e'}{2}\right)^{h'}\frac{i}{i'n' - in}\cos\theta.$$

5. Usually these terms have small coefficients and large arguments because $i'n' - in$ is generally a good-sized quantity.

But in certain cases the reverse is true. If

$$i' : i :: n : n',$$

or nearly so, then $i'n' - in = 0$, or nearly so, and the coefficient of δa becomes ∞ or very great.

Such terms, then, surpass enormously the others and instantly dominate δa in the series.

Now the relation

$$\frac{i'}{i} = \frac{n}{n'}$$

means that the mean motions are commensurable, inasmuch as i and i' always are whole numbers.

a, therefore, could not remain at the point of commensurability of period, since the periods are inversely as the mean motions, nor even in the immediate neighborhood of the point. For $i'n' - in$ continues large for some distance on either side of it.

6. For what happens consider the equation

$$\delta a = -2\frac{m'}{\mu}\left(\frac{e}{2}\right)^h\left(\frac{e'}{2}\right)^{h'} na\alpha f(\alpha)\cdot\frac{i}{i'n' - in}\cos\theta,$$

in which

$$\theta = (i'n' - in)\,t + i'\epsilon' - i\epsilon - k\varpi - k'\varpi'.$$

So long as n does not increase till $i'n' - in = 0$ for any value of θ, there is an oscillation of a, timed to θ, in which a never crosses the commensurable point. The farther away a is from this point for a given initial value of θ, the smaller δa and the less the swing, 1, because $i'n' - in$ is larger and the coefficient smaller; 2. because the period of θ is less.

7. When $i'n' - in$ approaches zero for general values of θ the action alters. Tisserand has discussed it in the case of the asteroids. There are three possible cases. Putting for simplicity for $i'n' - in$ the particular value $2n' - n_1$ we have:

1. $$(2n' - n_1)^2 > 2m'h_1^2 \cos^2 \frac{\theta_1}{2};$$

that is, when the constant $c^2 > 1$ or θ makes complete revolutions.

2. $$(2n' - n_1)^2 < 2m'h_1^2 \cos^2 \frac{\theta_1}{2};$$

that is, when $c^2 < 1$ or θ librates.

3. $$(2n' - n_1)^2 = 2m'h_1^2 \cos^2 \frac{\theta_1}{2},$$

the dividing value of the two in all of which

$$h_1^2 = 3\frac{n'^2}{a^2} e \frac{f(\alpha)}{a'},$$

and the subscripts denote the values at the start.

He found that the extreme values of n were in the several cases: approx.

1. $$\left\{2n' - \frac{n_1}{2} + \frac{1}{2}\sqrt{(n_1 - 2n')^2 - 2m'h_1^2 \cos^2 \frac{\theta_1}{2}}\right\}\frac{n_1}{n'} < n,$$

and $$n < \frac{n_1}{n'}\left\{2n' - \frac{n_1}{2} + \frac{1}{2}\sqrt{(n_1 - 2n')^2 + 2m'h_2' \sin^2 \frac{\theta_1}{2}}\right\}.$$

2. $$\left\{2n' - \frac{n_1}{2} - \frac{1}{2}\sqrt{(n_1 - 2n')^2 + 2m'h_1^2 \sin^2 \frac{\theta_1}{2}}\right\}\frac{n_1}{n'} < n,$$

and $$n < \frac{n_1}{n'}\left\{2n' - \frac{n_1}{2} + \frac{1}{2}\sqrt{(n_1 - 2n')^2 + 2m'h_1^2 \sin^2 \frac{\theta_1}{2}}\right\}.$$

3. $$n_1 \quad \text{and} \quad \frac{n_1^2}{2n'}.$$

In case 1. the particle never crosses the commensurable point; in 2. it librates over it; in 3. if the particle were at the point to start with, it would never leave it.

In case 1. the particle lingers relatively long in the neighborhood of the commensurable point, being then at the end of its swing. In case 2. the particle has a long swing, greater than in the case 1. as the equations show, since its outer limit is the same approx. while its inner is much farther in. Case 3. is a mere conceptual dividing line between the other two.

8. Tisserand's investigation takes no account of Jupiter's orbital excentricity, nor of higher terms, i. e., 2θ, etc., nor of $\frac{de}{dt}$ or $\frac{d\varpi}{dt}$. Nevertheless it sufficiently illustrates the swing in the several cases for our present purpose. More accurately considered by

another method I have shown elsewhere that among the asteroids around gaps $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$ and $\frac{2}{3}$ there are no instances of case 2,[1] no asteroids, that is, that exhibit libration.

The important thing in our present investigation is the amplitude of the swing. This it will be noted increases as the commensurable point is approached. There is thus an excursionary freedom near the points which is lacking elsewhere.

9. Since e is always less than unity the lower its power the greater δa and δn. The most effective terms, therefore, are those in which $i' - i = 1$, such as $\frac{1}{2}$, $\frac{2}{3}$ . . . $\frac{100}{101}$ and so on. The next most effective where $i' - i = 2$, such as $\frac{1}{3}$, $\frac{2}{4}$, $\frac{3}{5}$. These are followed by those of $i' - i = 3$, as $\frac{2}{5}$.

Each forms a series the members of which cluster closer together the nearer they approach their originating planet.

They also become more effective at close quarters. For the expression for δa is multiplied by i, which increases with approach. $f(\alpha)$ also increases as $\alpha = \frac{a}{a'}$ approaches unity.

Any difference of density in a revolving nebula is thus a starting point for accumulation. So soon as two or three particles have gathered together there they tend by increased mass to annex their neighbors. An embryo planet is thus formed. By the same principle it grows crescendo through an ever increasing sphere of influence until the commensurable points are too far apart to bridge by their oscillation the space between them.

10. This is the chief factor that has enabled the planets to sweep their surroundings clear. Nor is it evident that a ring of matter could not fold back into a localized mass, for though there are critical points at about 60° longitude from the Sun corresponding to Lagrange's equilateral triangle solution, speed and direction of motion must there be particularly adjusted to secure stability. The fact that four and only four asteroids survive to exemplify Lagrange's special case of stable motion is in itself evidence of the necessary rarity of the occurrence. It is certainly interesting that only with Jupiter are such outliers known. For, as we shall see later, (§11 and §21, 1, 2, 3) to suppose the planets generally to have started as collected masses is incompatible with their present positions; and though Jupiter alone of the major ones, may have done so, it is more analogic to suppose not.

11. Beyond a certain distance from the planet the commensurate-period swings no longer suffice to bridge the intervening space and the planet's annexing power stops. This happens somewhat before a certain place is reached where three potent periodic ratios succeed each other — $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$. For here the distances between the periodic points is greatly

[1] See Phil. Mag., March, 1912, and Astr. Journal, n° 630. The gap $\frac{2}{7}$ has been worked out by the writer, but not published.

increased, as Diagram I shows. The effect is well exemplified by the surviving asteroids indicated by the rough plot of their major axes in Diagram II.

At this distance a new action sets in. Though the character of its occasioning be the same it produces a very different outcome. The greater swing of the particles at these commensurate points together with a temporary massing of some of them near it conduces to collisions and near approaches between them which must end in a certain permanent combining there. A nucleus of consolidation is thus formed. This attracts other particles to it, gaining force by what it feeds on, until out of the once diffused mass a new planet comes into being which in its turn gathers to itself the matter about it.

A new planet tends to collect here: because the annexing power of the old has here ceased while at the same time the scattered constituents to compose it are here aided to combine by the very potent commensurability perturbations of its already formed neighbor.

So soon as it has come into being another begins to be beyond it, called up in the same manner. It could not do so earlier because the most important *deus ex machina* in the matter, the perturbation of its predecessor, was lacking.

So the process goes on, each planet acting as a sort of elder sister in bringing up the next.

That such must have been the genesis of the several planets is evident when we consider that had each arisen of itself out of surrounding matter there would have been in celestial mechanics nothing to prevent their being situated in almost any relative positions other than the peculiar one in which they actually stand.

That all the planets are ordered where this reasoning would place them a glance at the Diagrams III and IV will show.

12. We now come to an important corroborative bit of telltale evidence. It will be noticed that the several planets are not quite at the commensurate points. They are in fact all just inside them, as will appear more conspicuously in the sequel. Now this offing turns out to be an inevitable consequence of the same cause that tended to mass them originally at the commensurate points. It thus affords visible confirmation of the former's truth. This we shall now show.

So far we have considered only the commensurability terms which depend on the first power of the masses. We now proceed to terms of the second order in them.

To get the second order terms the elements entering the first must themselves be deemed variable. As the differentials of the elements include the mass, those to the second order introduce by substitution the second order of the masses. We shall denominate the first order increments by $\delta_1 a$ etc.; the second order ones by $\delta_2 a$.

Taking both into account,

$$a \text{ becomes } a + \delta_1 a + \delta_2 a,$$

and

$$n \quad \text{“} \quad n + \delta_1 n + \delta_2 n.$$

Introduce these into the equation of an elliptic orbit

$$n^2 a^3 = \mathrm{f}\mu,$$

and it becomes, where $\mu = 1 + m$ and f is the constant of gravitation,

$$(n + \delta_1 n + \delta_2 n)^2 (a + \delta_1 a + \delta_2 a)^3 = n^2 a^3 = \mathrm{f}\mu.$$

Expanding and equating like powers of m' we get:

$$\delta_1 n = -\frac{3n}{2a}\delta_1 a,$$

$$\delta_2 n = -\frac{3n}{2a}\delta_2 a + \frac{15}{8}\frac{n}{a^2}(\delta_1 a)^2.$$

$\int n dt$ therefore becomes

$$n dt - \frac{3n}{2a}\int \delta_1 a\, dt - \frac{3n}{2a}\int d_2 a\, dt + \frac{15n}{8a^2}\int (\delta_1 a)^2 dt.$$

Now, there are no secular terms in a or n to the first order of the masses, as Laplace and Lagrange showed. Nor are there any such to the second order, as Poisson proved. But consider the third term in the perturbation.

Since

$$\delta_1 a = -2\frac{m'}{\mu} na\alpha f(\alpha)\left(\frac{e}{2}\right)^h \left(\frac{e'}{2}\right)^{h'} \frac{i}{i'n' - in}\cos\theta,$$

$$(\delta_1 a)^2 = 4\left(\frac{m'}{\mu}\right)^2 n^2 a^2 \alpha^2 [f(\alpha)]^2 \left(\frac{e}{2}\right)^{2h} \left(\frac{e'}{2}\right)^{2h'} \frac{i^2}{(i'n' - in)^2}\cos^2\theta.$$

Now

$$\cos^2\theta = \tfrac{1}{2} + \tfrac{1}{2}\cos 2\theta.$$

Consequently

$$\int (\delta_1 a)^2 dt = 2\left(\frac{m'}{\mu}\right)^2 n^2 a^2 \alpha^2 [f(\alpha)]^2 \left(\frac{e}{2}\right)^{2h} \left(\frac{e'}{2}\right)^{2h'} \frac{i^2}{(i'n' - in)^2} t + \text{a periodic term} = s_2 t + \text{a periodic term}.$$

Here then we have a permanent addition made to the mean motion, nt becoming $nt + s_2 t = (n + s_2)\, t$ and since $(\delta_1 a)^2$ is a square, s_2 will always be positive. This of course applies to all the periodic terms in $\delta_1 a$ but the only important one is that near the commensurable point, since $i'n' - in$ is there very small.

13. Suppose now a particle or planet close to the commensurable point inside it. The mean motion in consequence of the above perturbation will be permanently increased,

and therefore the major axis be permanently decreased. In other words the particle or planet will be pushed sunward. If it be still where $i'n' - in$ be small it will suffer another push, and so on until it has reached a place where the perturbation is no longer sensible.

Suppose the particle outside the point at the place where the perturbation begins to be sensible. As $(\delta_1 a)^2$ is necessarily positive whatever the sign of $\delta_1 a$ it will be pushed in, the action becoming more violent till the body reaches the commensurable point over which it will go to join in its turn those previously displaced. Thus no particles or planets can remain in this swept swarth, which on both sides braids the point.

14. We thus reach from theory two conclusions:

1. All the planets were originally forced to form where the important and closely lying commensurable points $\frac{1}{2}$, $\frac{2}{5}$, or $\frac{1}{3}$, and in one case $\frac{3}{5}$, existed with their neighbors; which of these points it was being determined by the perturbations themselves.

2. Each planet was at the same time pushed somewhat sunward by perturbation due to the same cause but in the second order of the masses.

15. We shall now see by turning to the planets themselves how dutifully their major axes fall into line with these formative effects of theory. To do this we shall begin by calculating the change in the major axes for the commensurate period terms in $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$ and $\frac{3}{5}$ of the several mean motions due the important terms in the first order in the masses. Those to the second are, for the secular terms, their squares. Actually the results here given are for the present positions of the planets, but the deductions to be drawn from them are the same as if they were for the commensurate points.

Perturbations of the Major Axis.

Terms of Long Period.

Uranus and Neptune.

$\frac{1}{2}$

$$\begin{cases} \delta a = 4.947\, m' a\, \alpha \dfrac{e}{2} \dfrac{n}{2n' - n} \cos\{(2n' - n)t + 2\epsilon' - \epsilon - \varpi\} \dfrac{1}{\mu} \\ \delta a' = -7.907\, m a'\, \alpha \dfrac{e}{2} \quad " \quad " \quad " \quad " \quad " \dfrac{1}{\mu'} \\ \delta a = -1.813\, m' a\, \alpha \dfrac{e'}{2} \dfrac{n}{2n' - n} \cos\{(2n' - n)t + 2\epsilon' - \epsilon - \varpi'\} \dfrac{1}{\mu} \\ \delta a' = 3.226\, m a'\, \alpha \dfrac{e'}{2} \quad " \quad " \quad " \quad " \quad " \dfrac{1}{\mu'} \end{cases}$$

Uranus and Saturn.

$$\left\{\begin{array}{lll}
\delta a &= -5.387\, m' a\, \alpha \left(\frac{e}{2}\right)^2 \frac{n}{3n'-n} \cos\{(3n'-n)t + 3\epsilon' - \epsilon - 2\varpi\} \frac{1}{\mu} \\
\delta a' &= \quad 11.396\, m\, a'\, \alpha \left(\frac{e}{2}\right)^2 \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= \quad 19.256\, m' a\, \alpha \frac{e e'}{4} \frac{n}{3n'-n} \cos\{(3n'-n)t + 3\epsilon' - \epsilon - \varpi - \varpi'\} \frac{1}{\mu} \\
\delta a' &= -40.737\, m\, a'\, \alpha \frac{e e'}{4} \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= -3.290\, m' a\, \alpha \left(\frac{e'}{2}\right)^2 \frac{n}{3n'-n} \cos\{(3n'-n)t + 3\epsilon' - \epsilon - 2\varpi'\} \frac{1}{\mu} \\
\delta a' &= \quad 9.701\, m\, a'\, \alpha \left(\frac{e'}{2}\right)^2 \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'}
\end{array}\right.$$

Saturn and Jupiter.

$$\left\{\begin{array}{lll}
\delta a &= \quad 37.23\, m' a\, \alpha \left(\frac{e}{2}\right)^3 \frac{n}{5n'-2n} \cos\{(5n'-2n)t + 5\epsilon' - 2\epsilon - 3\varpi\} \frac{1}{\mu} \\
\delta a' &= -68.74\, m\, a' \alpha \left(\frac{e}{2}\right)^3 \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= -186.0\, m' a\, \alpha \left(\frac{e}{2}\right)^2 \frac{e'}{2} \frac{n}{5n'-2n} \cos\{(5n'-2n)t + 5\epsilon' - 2\epsilon - 2\varpi - \varpi'\} \frac{1}{\mu} \\
\delta a' &= \quad 343.4\, m\, a'\, \alpha \left(\frac{e}{2}\right)^2 \frac{e'}{2} \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= \quad 307.7\, m' a\, \alpha \left(\frac{e}{2}\right)\left(\frac{e'}{2}\right)^2 \frac{n}{5n'-2n} \cos\{(5n'-2n)t + 5\epsilon' - 2\epsilon - \varpi - 2\varpi'\} \frac{1}{\mu} \\
\delta a' &= -568.1\, m\, a'\, \alpha \left(\frac{e}{2}\right)\left(\frac{e'}{2}\right)^2 \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= -167.9\, m' a\, \alpha \left(\frac{e'}{2}\right)^3 \frac{n}{5n'-2n} \cos\{(5n'-2n)t + 5\epsilon' - 2\epsilon - 3\varpi'\} \frac{1}{\mu} \\
\delta a' &= \quad 302.9\, m\, a'\, \alpha \left(\frac{e'}{2}\right)^3 \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'}
\end{array}\right.$$

Venus and the Earth.

$$\left\{\begin{array}{lll}
\delta a &= -87.56\, m' a\, \alpha \left(\frac{e}{2}\right)^2 \frac{n}{5n'-3n} \cos\{(5n'-3n)t + 5\epsilon' - 3\epsilon - 2\varpi\} \frac{1}{\mu} \\
\delta a' &= \quad 124.11\, m\, a' \alpha \left(\frac{e}{2}\right)^2 \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= \quad 227.81\, m' a\, \alpha \frac{e}{2} \frac{e'}{2} \frac{n}{5n'-3n} \cos\{(5n'-3n)t + 5\epsilon' - 3\epsilon - \varpi - \varpi'\} \frac{1}{\mu} \\
\delta a' &= -322.92\, m\, a' \alpha \frac{e}{2} \frac{e'}{2} \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'} \\
\delta a &= -147.22\, m' a\, \alpha \left(\frac{e'}{2}\right)^2 \frac{n}{5n'-3n} \cos\{(5n'-3n)t + 5\epsilon' - 3\epsilon - 2\varpi'\} \frac{1}{\mu} \\
\delta a' &= \quad 208.68\, m\, a' \alpha \left(\frac{e'}{2}\right)^2 \quad " \quad " \quad " \quad " \quad " \quad " \quad \frac{1}{\mu'}
\end{array}\right.$$

From them we note that:

1. The inner planet is *caeteris paribus* more potent than the outer.

2. The greater the mass of the disturber and, in certain cases, the greater the excentricity of either the disturber or the disturbed the greater the effect.

16. In most cases the effect of each component of the pair is somewhat masked at first by the simultaneous action of the other. But fortunately there is a set of instances in which the effect of one is sensibly eliminated, allowing that of the other to show unhid. This is the case with Jupiter and the asteroids. So small are the masses of the latter, taken either singly or together, that they produce no perceptible effect on Jupiter, while, on the other hand, Jupiter's giant mass enables us to mark his action as through a magnifying glass, minutely and alone.

17. Diagram V gives the plot of the major axes of all the asteroids except those that have nothing to do with the argument: the four at Jupiter's distance, Achilles, Nestor, Hector and Patroclus; Thule just inside the $\frac{3}{4}$ point; and at the other end Hungaria and Eros.

We notice;

1. The gathering of the great bulk of the asteroids around the commensurate periods $\frac{1}{2}$, $\frac{2}{5}$, and $\frac{1}{3}$.

2. The swaths cut by the terms in m'^2 at the points, nearly symmetric on either side of them.

3. Their width corresponding to the importance of the terms; that is, to the distances from the commensurable points at which the effect becomes insensible or counteracted by other causes.

4. The asteroidal condensation at their inner edges, the embryos of planets destined in this case never to be born.

5. The fact that had the asteroids been sufficiently numerous they must have collected at the $\frac{2}{5}$ point and gathered in the outliers there.

No laboratory experiment could more prettily exemplify a law than does this asteroid witness in the sky.

18. Turning now to the outer planets and remembering their respective masses and eccentricities,

	Mass.	Ratio to the next in order.	Excentricity.
Jupiter	$\frac{1}{1047.35}$	3.4	.04836
Saturn	$\frac{1}{3502}$	6.4	.05584
Uranus	$\frac{1}{22760}$	.84	.04708
Neptune	$\frac{1}{19000}$		.00854

and that the inner are, other things equal, three or four times as effective from position as the outer of each pair, we see that in all cases we ought to have just what we observe: the inner outside, the outer inside the commensurate points, since what we now perceive is the difference of the sunward shoves of the two.

19. Next the inner or terrestrial planets. The Earth and Mars repeat the story of the outer ones at $\frac{1}{2}$, Venus and the Earth do the same at $\frac{3}{5}$.[2] That this should be $\frac{3}{5}$ instead of $\frac{1}{2}$ is apparently to be ascribed to the more nearly equal perturbation of the two for points between. For though Venus' mass is less, her inner position makes up for it, giving her a slight mastery over the debatable territory.

Thus for Venus:	and for the Earth-Moon
$m = .805$	$m' = 1.$
$a = .723$	$a' = 1.$
$e = .0068$	$e' = .0167$

and

$$\frac{\delta a}{\delta a'} = \frac{\text{coef. } m'a}{\text{coef. } ma'} = \frac{7}{11}.$$

Mutually regarded Venus' pull therefore outdoes the Earth's. So that here again the action is as for the outer planets. Lastly, in the case of Mercury and Venus, Mercury's mass, $\frac{1}{23}$ of the Earth, being only $\frac{1}{18}$ of Venus', is so small that position cannot make up for it and Venus thrusts Mercury sunward more than she herself is pulled in the same direction, the period being $\frac{2}{5}$.

20. In explanation of why the particular commensurate relations exist in the several cases the following may be offered. When the action of the more potent planet greatly exceeds the other's it sweeps to itself particles farther away than would otherwise be possible. As the ratio of the two pulls increases toward equality the eminent domain of the stronger shrinks, allowing the other to form nearer. Thus the commensurate point passes in from $\frac{1}{3}$ to $\frac{2}{5}$, $\frac{1}{2}$ and finally $\frac{3}{5}$. Now the ratio of the two pulls is the nearest unity between Venus and the Earth; less between Uranus and Neptune, still less between Jupiter and Saturn, and less still between Saturn and Uranus, as calculation from Table I will show. And this is the order of their commensurate points: $\frac{3}{5}$, $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$. The masses themselves which brought this about must be ascribed to initial differing densities of the originally scattered nebula. Between Mercury and Venus the ratio is $\frac{2}{5}$, as it should be. Between Jupiter and the asteroids $\frac{2}{5}$ instead of $\frac{1}{3}$, because the second order terms have pushed them from him instead of pulling them toward him had they lain outside. For the Earth and Mars we should have expected $\frac{1}{3}$ instead of $\frac{1}{2}$, but this may be due to the

[2] $\frac{8}{13}$ is now nearer, but was a much less potent period in the past.

continued action of the gigantic Jupiter in this territory, or it may be that a second origin of condensation started with the Earth while Jupiter fashioned the outer planets.

21. From the foregoing some interesting deductions are possible:

1. The planets grew out of scattered material. For had they arisen from already more or less complete nuclei these could not have borne to one another the general commensurate relation of mean motions existent today.

2. Each brought the next one into being by the perturbation it induced in the scattered material at a definite distance from it.

3. Jupiter was the starting point, certainly as regards the major planets; and is the only one among them that could have had a nucleus at the start, though that, too, may equally have been lacking.

4. After this was formed Saturn, then Uranus, and then Neptune.

This order is curiously supported by the present mean densities of the four. Their densities and masses are:—

	Density ($\oplus$ = 1).	Mass.
Jupiter	.24	$\frac{1}{1047.35}$
Saturn	.13	$\frac{1}{3502}$
Uranus	.22	$\frac{1}{22760}$
Neptune	.20	$\frac{1}{19000}$

Density is determined by:

1. Original mass;
2. Age.

Now the younger a planet and the greater the mass, the longer must it take to cool and condense. If, then, Neptune had led off it should have now much the greatest density, followed by Uranus, and so on. If, however, Jupiter started first, his mass would to a certain extent offset his age, Saturn might be what he is, while Uranus and Neptune being smaller might already have caught up in the race for condensation, thus equalizing them with Jupiter, which we observe to be the case.

5. The asteroids point unmistakably to such a genesis, missed in the making.

6. The inner planets betray *inter se* the action of the same law, and dovetail into the major ones through the $\frac{2}{5}$ relation again between Mars and the asteroids.

We thus close with the law we enunciated: *Each planet has formed the next in the series at one of the adjacent commensurable-period points, corresponding to* $\frac{1}{2}$, $\frac{2}{5}$, $\frac{1}{3}$, *and in one instance* $\frac{3}{5}$, *of its mean motion, each then displacing the other slightly sunward, thus making of the solar system an articulated whole, an inorganic organism, which not only evolved but evolved in a definite order, the steps of which celestial mechanics enables us to retrace.*

The above planetary law may perhaps be likened to Mendelief's law for the elements. It, too, admits of prediction. Thus in conclusion I venture to forecast that when the nearest trans-Neptunian planet is detected it will be found to have a major axis of very approximately 47.5 astronomical units, and from its position a mass comparable with that of Neptune, though probably less; while, if it follows a feature of the satellite systems which I have pointed out elsewhere, its excentricity should be considerable, with an inclination to match.

April 14, 1913.

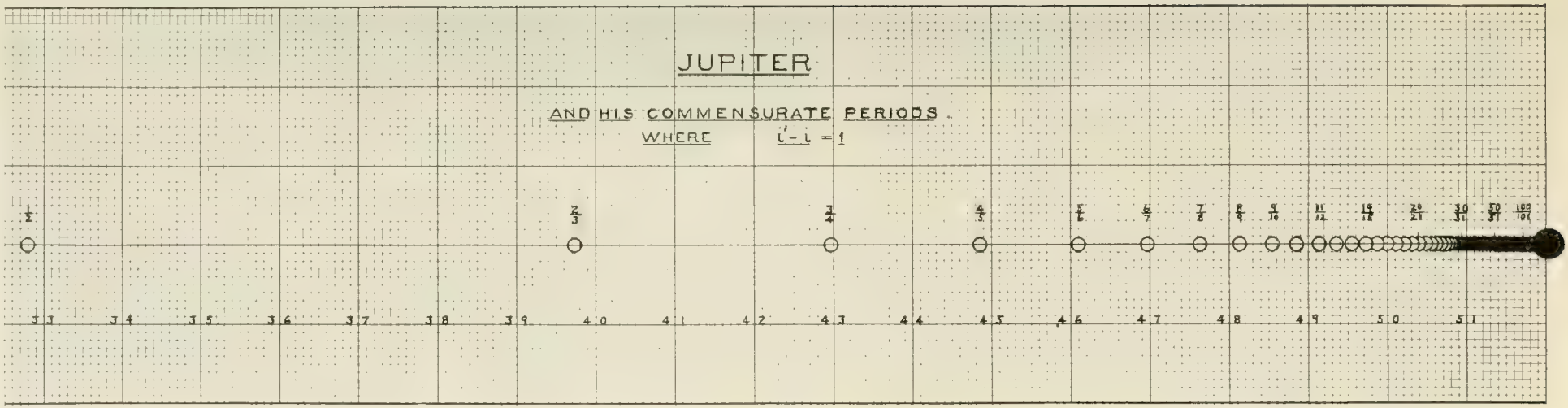
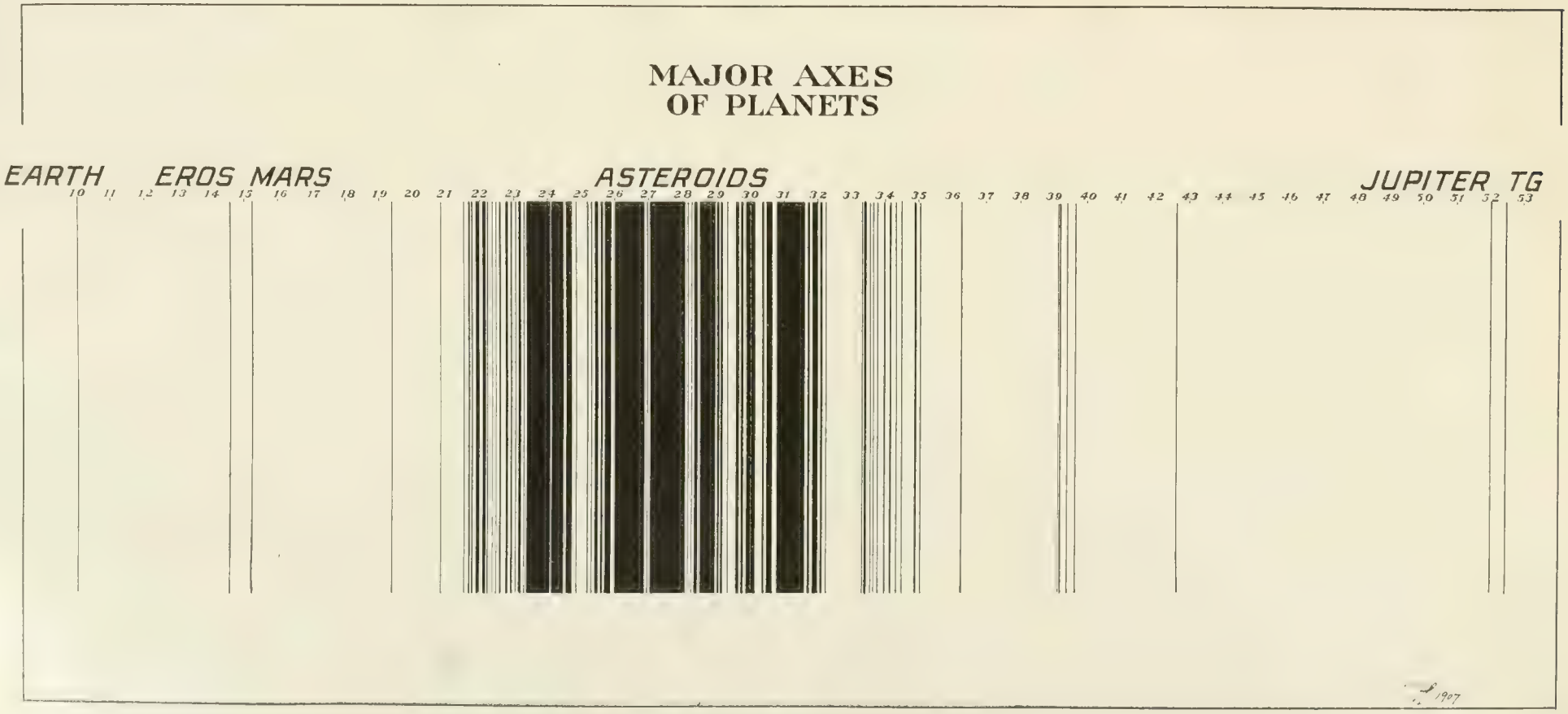


Diagram I.



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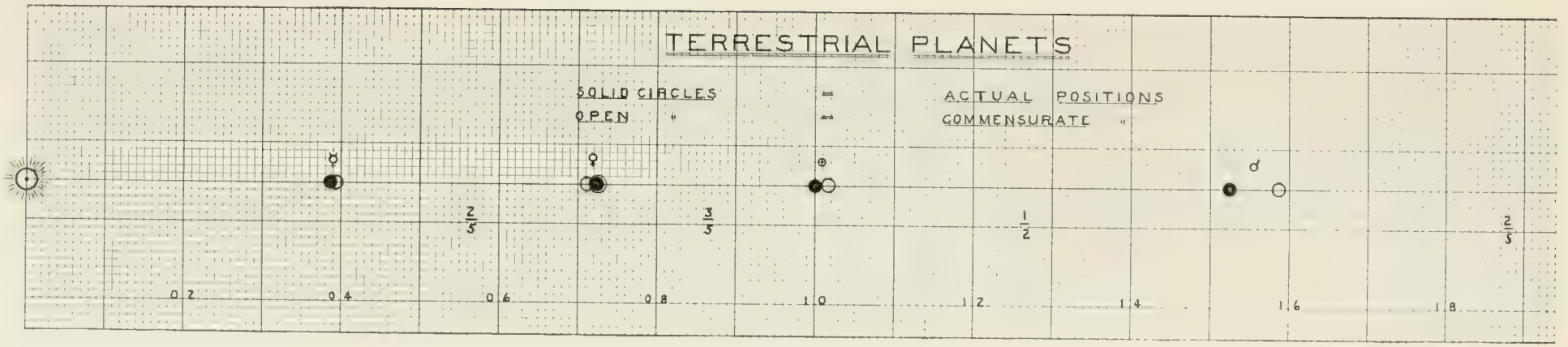
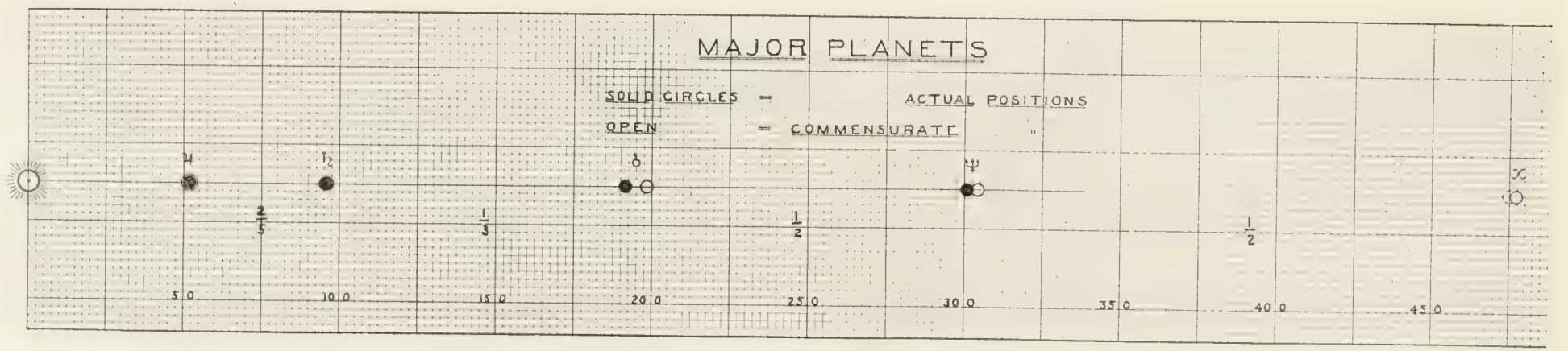


DIAGRAM III.



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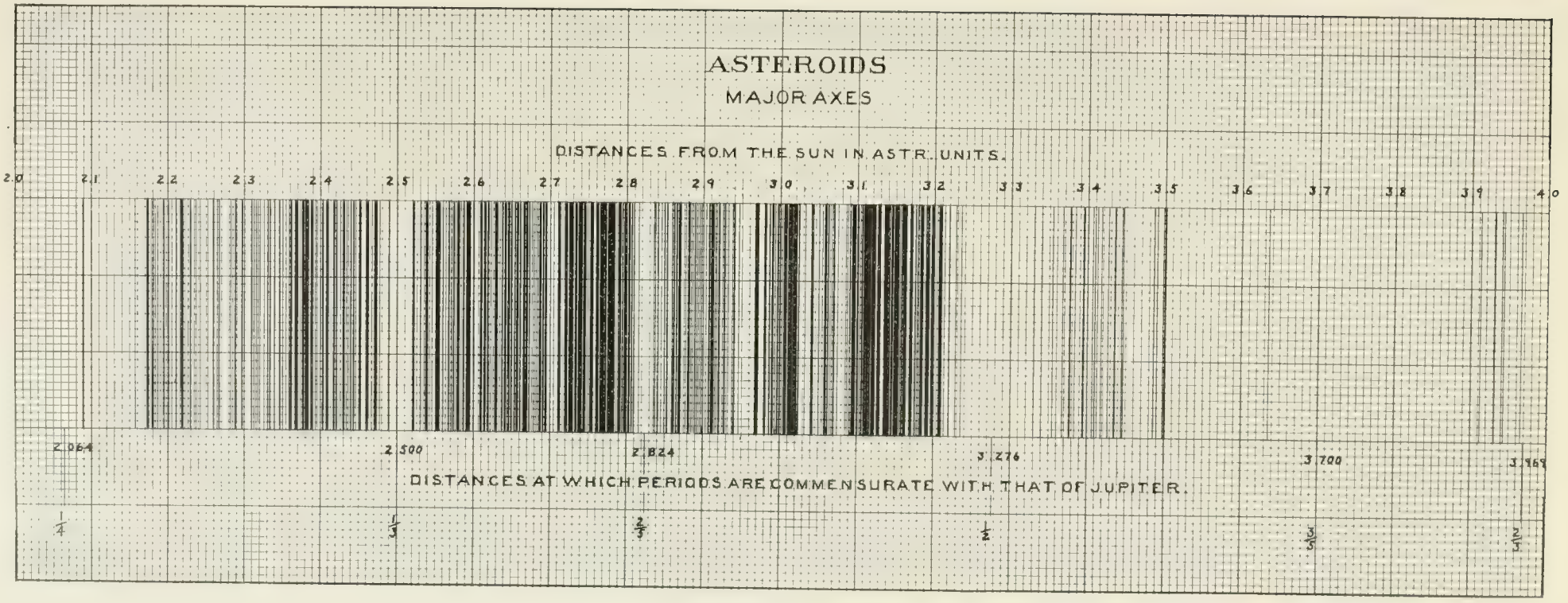
ASTEROIDS
MAJOR AXES
DISTANCES FROM THE SUN IN ASTR. UNITS.
2.0
2.1
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3.4
3.5
3.6
3.7
3.8
3.9
4.0
2.064
2.500
2.824
3.276
3.700
3.969
DISTANCES AT WHICH PERIODS ARE COMMENSURATE WITH THAT OF JUPITER.
1/4
1/3
2/5
1/2
3/5
2/3

DIAGRAM V

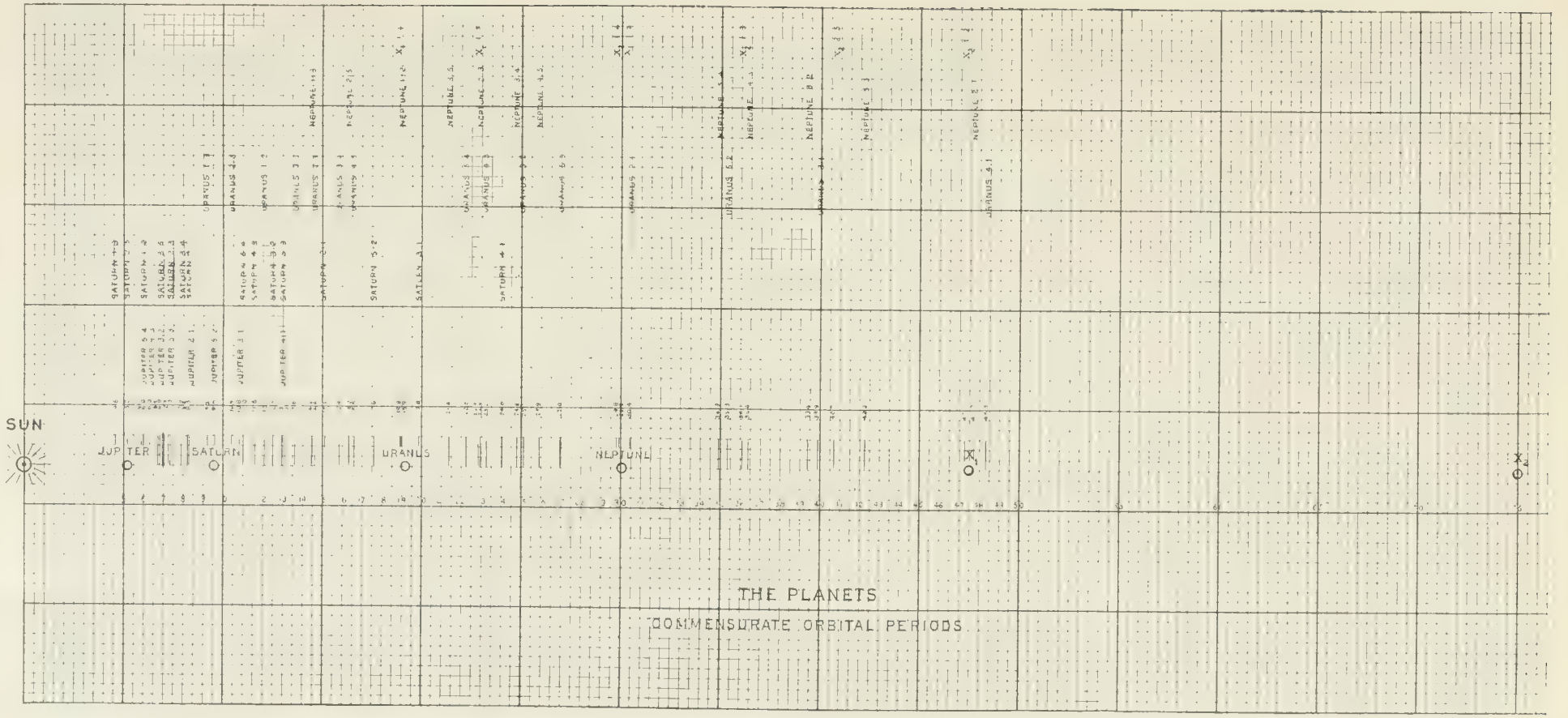
SUN
JUPITER
SATURN
URANUS
NEPTUNE
THE PLANETS
COMMENSURATE ORBITAL PERIODS

DIAGRAM VI.

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MEMOIRS

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OF

ARTS AND SCIENCES

VOL. XIV.—NO. II

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WAVERLEY RESEARCHES IN THE PATHOLOGY OF THE FEEBLE-MINDED.

(Research Series, Cases I to X.)

EDITED BY

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WITH THE COLLABORATION OF

ANNIE E. TAFT, M.D., Special Investigator, Massachusetts Commission on Mental Diseases, and Custodian of the Neuropathological Collection, Department of Neuropathology, Harvard Medical School.

I. General Aspects of the Brain Anatomy in the Feeble-Minded, with partial Bibliography . . 23
E. E. Southard.

II. Clinical, Anatomical, and Brief Histological Description of Ten Cases of Feeble-Mindedness, with 84 plates (Waverley Research Series, Cases I–X) 59
E. E. Southard and Annie E. Taft.

III. Neuropathological Correlations with Clinical and Psychometric Findings in Feeble-Mindedness (Waverley Research Series, Cases I–X). 109
E. E. Southard and Annie E. Taft.

PREFACE.

We present herein the first-fruits of an orienting study of some of the more fundamental problems of feeble-mindedness. Rarely has the problem of feeble-mindedness been attacked fundamentally for its own sake. Yet in recent years and in the immediate present the representatives of numerous and varied interests clamor for light upon what appear the limiting problems of their special fields. But what can the workers in feeble-mindedness as such and for its own sake say to

a) the *educators*, responsible for "laggards," truants, "terrors," "exceptionals," "ungraded," specially graded, retarded, and backward children;

b) the *court authorities*, to whom the educators' problems in part drift and figure as psychopathic cases, defective delinquents, prostitutes, and the like;

c) the *social workers*, sometimes over-ready to tar all these cases with the same brush as "mental";

d) the *eugenists*, who either as Galtonians or as Mendelians, often tend to treat as units and thought-counters all sorts of feeble-mindedness and perhaps even epilepsy under a single caption;

e) the generalizing *biologists*, with their counsel of perfection in the guise of sterilization of the potential parents of more feeble-minded;

f) the *syphilographers* and *antialcoholists*, who need facts for their propagandas and at any rate must not universalize what facts are obtainable;

g) the *legislators* and alert guardians of the public purse, who are promised, in lieu of impractical sterilization, a program of segregation — What can the workers in feeble-mindedness offer to all these inquirers?

Satisfied for the moment with an astonishing and unfamiliar publicity, the special workers in feeble-mindedness shortly turn to fundamentals. Assured in our own minds that not all school "problems" are feeble-minded, that not all delinquents are defective, that not all feeble-minded are institutional subjects, that Pearson and Davenport should not lump and unify so medically obvious a *pot-pourri* as feeble-mindedness, that sterilization is a program whose first physiological lines have not been laid down, that syphilis and alcohol have not had their shares demarcated in the matter of feeble-mindedness,

and that legislators rush in where specialists find no footway, we run to our books. Mierzejewski, Bourneville, Hammarberg, Wilmarth, Tredgold, Bolton, these and others have done their part, perhaps most notably Bourneville. Even Germany has little to offer in the fundamentals, save perhaps the suggestions of the lamented Alzheimer. The great foundations have neglected feeble-mindedness (there is grim humor in the fact that their proposals will often come to naught through the existence of these very feeble-minded whom the great foundations neglect!).

Yet it is not merely the present-day neglect of fundamentals in feeble-mindedness that justifies our undertaking. Other sciences have advanced in the meantime. What would not the modern ideas of glandular dysfunction have meant to Bourneville? How Hammarberg would have rejoiced had the modern work of the cortex-topographers enabled him to omit a large part of his monograph and rush on to deeper studies in feeble-mindedness? How Wilmarth would have enjoyed the resources of a modern laboratory!

These considerations have been set forth more extensively, though still too briefly, in Article I. Here we wish to say that we are minded to present a series of studies of the anatomy, and especially of the brain anatomy, of the feeble-minded (including idiots, imbeciles, and a variety of subnormals under that general term) to which we set the provisional terminus of fifty cases. Until we have presented at least fifty cases from an identical point of view, we feel that we shall hardly be warranted in drawing conclusions. Still, epicritical remarks will be in order with each group of ten cases presented. We plan to present perhaps ten cases a year. The great foundations aforesaid, which have so neglected the topic, might of course speed up the work appreciably; yet it must be granted that every case of feeble-mindedness is so much a unique, not to say Argus-eyed, a problem that speeding-up by funds alone is hardly a practical policy. More living brains are needed to work out the problems of the brains of feeble-minded, whether living or dead — but *cadit quaestio, that* is the urgent lack of mental hygiene as a whole.

We must accord due credit and extend our thanks to the various clinical and post mortem observers who have rendered the work possible, especially to the Waverley School workers, to Dr. Myrtelle M. Canavan of the Pathological Service of the Massachusetts Commission on Mental Diseases, who has performed most of the recent autopsies, and to Dr. Annie E. Taft, Custodian of the Neuropathological Collection, Harvard Medical School, who has been charged with much of the brain analysis. We should not omit to call attention to the excellence of the photographic work of Mr. Herbert W. Taylor, Of great importance also is the work of the technicians, among whom we may mention Miss Ellen R. Scott and Miss Mae Cameron.

Perhaps the most interesting endeavor in the present volume is the attempt to match

brain complexity with mental capacity. To say nothing of the mind-and-brain problem (the less mind, the less brain, and *vice versa*, where "less" is taken not *too* quantitatively), we feel that the whole problem of "mental tests," now *sub judice*, needs anatomical support and anatomical critique. Various authorities glibly discard all "tests"—mind cannot be measured, that is an *à priori* certainty! Other persons, chiefly of the bureaucratizing group, would let fly at the institutions cases "feeble-minded" by a Binet-Simon fraction, particularly if they be antisocial and affected by symptoms never considered by Binet and Simon. The epicritical remarks of the present volume, provisional in character, are therefore levelled at the question of *matching testable mind with measurable brain*. The situation appears on the whole rather favorable. On the basis of the clinical and anatomical details of Article II, Article III goes on to the more doubtful matter of evaluation. The skeptical may confine their attentions to Articles I and II.

A second volume, dealing with Cases XI to XX (including also "Mongolians"), is within hail. Therein we hope to deal still further with the major problems herein touched, such as

a) the correlation of mental and cerebral measurements.

b) the theoretically preventable group, (e. g. syphilitic, post-poliomyelitic).

The grant for the investigation and its publication is from a private endowment of the Massachusetts School for the Feeble-minded. A grant for publication of suitable and numerous plates has been received from Dr. W. N. Bullard, whom we would like to thank in fullest measure.

Walter E. Fernald,
E. E. Southard,
Editors.

I.

GENERAL ASPECTS OF THE BRAIN ANATOMY OF THE FEEBLE-MINDED.

E. E. Southard.

I.

GENERAL ASPECTS OF THE BRAIN ANATOMY OF THE FEEBLE-MINDED.

E. E. Southard.

Abstract.— Small amount of intensive anatomical work available in the literature (Bourneville, Hammarberg, Tredgold, Bolton). Research emphasis on other aspects (heredity, mental tests, social service, education).

Situation in the biology of feeble-mindedness (Ballantyne). The question whether any feeble-minded persons have normal-looking brains. Relative absence of work on the brains of feeble-minded of higher grades. Modern knowledge of cortex topography.

Tredgold's distinction of primary and secondary amentia ("germinal blight" versus "arrest"). Classification of W. W. Ireland. Exogenous nature of numerous cases (intrauterine lesions). Tredgold's view that germinal variations are pathological and not spontaneous. The suggestion that germ cells may be poisoned. Brain findings in exogenous cases.

Anatomical classification, Bourneville, 1889; Bourneville's researches. Hammarberg's report on 9 cases (psychic defects connected with defective nerve cells in the cerebral cortex). Idiocy thought to be due to developmental check in later foetal life. Marked weak-mindedness thought to be due to arrest of development in a stage normal for the first years of life. A third group with focal factors of inhibition occurring during the first year of life.

Most of Hammarberg's work devoted to the microscopy of the *normal* cortex. Necessity of recognizing certain shrinkage processes as artificial. Hammarberg's claim that disorderly arrangement of cortical cells is also found in normal material (undeveloped cells frequently taken for atrophic ones).

Summary of Hammarberg's work with 4 cases of idiocy, 2 of marked weak-mindedness, 3 of slighter degrees of weak-mindedness.

Tredgold's conclusion that the essential basis of primary amentia is cellular, due to an imperfect or arrested development of cerebral neurones. Tredgold's belief that irregular arrangement of cells is characteristic of feeble-mindedness material.

Situation in the anatomy of feeble-mindedness as presented at the Medical Congress in Paris in 1900.

Work of Mierzejewski (anatomical lesions are developmental deviations). Mierzejewski's special group of cases in which the gray matter is disproportionately large as compared with the white matter. Heterotopia.

Classification of Shuttleworth and Fletcher-Beach; microcephaly probably not caused by premature synostosis of cranial sutures. Congenital hydrocephalus extends the lateral ventricles lengthwise, acquired vertically and transversely (Meynert); scaphocephaly; Mongolian idiocy; other groups.

Syphilis not a common cause of feeble-mindedness; juvenile general paresis as first observed by Clouston; traumatic cases; so-called hypertrophy.

American literature. Wilmarth's study. 25 cases in 100 yielded no brain lesions to gross analysis. Quotations from Wilmarth's conclusions.

Problems suggested by the literature of the brain anatomy of the feeble-minded.

We present herewith the first section of the Waverley Researches in the Anatomy of the Feeble-Minded begun in 1913 under the auspices of the Massachusetts School for the Feeble-Minded. This first section of Researches contains

I, a general introduction to the topic of brain anatomy of feeble-mindedness,

II, a particular description of ten instances of feeble-mindedness of various grades, together with autopsy and microscopic findings, and

III, attempts at correlating the brain anatomy and histology with clinical and especially with psychometric (mental test) findings. Further studies are under contemplation with the object of gradually enlarging the brain series, from which, when it shall have contained say 50 brains, we may be able to draw sound conclusions.

Let us note at the outset our surprise at the extraordinary neglect into which this topic has fallen. Bourneville, Hammarberg, Wilmarth, are the older names of workers contributing carefully sifted cases studied in the interest of feeble-mindedness. Most authors deal with feeble-mindedness as a stalking-horse in some other scientific pursuit, teratological, embryological, anatomical, histological, etc. We claim for the present work that, despite numerous theoretical and ancillary interests, *we have studied feeble-mindedness from the standpoint of feeble-mindedness.* In particular we have tried to place our cases in a tentative order of mental strength, correlating brain appearances with mental tests. Our purpose has been at least as much to evaluate the mental tests by throwing their results against the brain pictures as it might have been to evaluate the brain pictures in the light of mental tests. We may anticipate our conclusions so far as to say that, roughly speaking, the architectonic order in which the brains arranged themselves corresponds to the psychometric order indicated by the mental tests.

Thus, we must emphasize, we are not here studying the brain for the brain's sake, or the mental tests for their sake alone. We have no eugenic, economic or social interests paramount in the present inquiry.

This first series of ten cases is intended as an orienting and introductory series to a more extended study which at present contemplates the examination by modern methods of 40 more cases, to make up a series of 50, from which series it may be safe to draw provisional conclusions. The first series has accordingly been made to include all available material from several sources which was found to comport with certain necessities of modern research in feeble-mindedness.

One might readily get the impression that the literature would be found to contain enough properly examined material from which to draw conclusions. One would have in mind the Bicêtre reports of Bourneville, beginning in 1881 and continued at successive intervals for 20 years. One would have in mind the masterly work done in Sweden by

Hammarberg and published after his death at Upsala in 1895. Another source of information would be the work done by Dr. A. F. Tredgold under the London County Council early in this century and published in Mott's Archives of Neurology in 1903, embodied in Tredgold's book on Mental Deficiency, second edition, 1914.

Then one would find the work of J. S. Bolton "On the Histological Basis of Amentia and Dementia," published in the same volume of Archives of Neurology and later embodied in a more popularized form in Bolton's book "On the Brain in Health and Disease," London, 1914.

In the textbooks on feeble-mindedness, one would find numerous references to Italian work in anatomy. In various textbooks one would find references to considerable work on the anatomy of feeble-mindedness (see for example, the literary references in Ziehen's account of "Diseases of the Brain and Meninges in Childhood," 1912).

In point of fact, however, the anatomy of feeble-mindedness has not been attacked systematically over a period of years having due regard not only to clinical features, but to anatomical and histological features.

On the whole, the remarkable developments in education of the feeble-minded following the initial work of Séguin have developed almost independently of the anatomical, histological and physiological sides of the topic. With the developments of recent years a tremendous emphasis has begun to be laid upon the hereditary and eugenic aspects of feeble-mindedness, and a large effort has been expended upon certain applications of psychology to the mental testing of the feeble-minded. But neither the hereditarians nor the applied psychologists have particularly concerned themselves with the broader biological aspects of the whole topic. We must confess that on the whole, the broader biological aspects of feeble-mindedness have tended to be concealed in the mass of practical applications which the mental testing methods have unfolded and the web of promises spun by the eugenist. Accordingly we face a situation with the feeble-minded in which their education, their heredity, and the methods of their mental testing have absorbed interest. In the spring of 1915, however, the note of research in this field was struck at the National Conference of Charities and Correction, perhaps somewhat to the astonishment of the listeners, who have been far more interested in social service than in the more recondite aspects of research. However, educational research, eugenic research, research in applied psychology, and sociological research, all need effort on the biological basis. It seems as if this basis had been sadly and almost inconceivably neglected in the past.

What is the present situation, biologically speaking? The *biologist*, if asked the nature and measure of his interest in feeble-mindedness, would be apt to answer some-

what as follows: The institutions might supply us with a vast deal of material of the greatest interest from such a standpoint, for example, as that of Ballantyne, whose fundamental collection of material on "Antenatal Pathology and Hygiene" was published in 1902 and 1904 respectively. There should be much, the biologist might continue, of great interest from the standpoint of monstrosities, and the teratologist might be able to unravel any number of intricate problems of the mechanics of development from the anatomical material of institutions for the feeble-minded. He would have to consider not merely the immediate pathology of the antenatal period, but also the postponed effects which Ballantyne has emphasized, and not only the postponed effects in the neonatal period of life, but also its postponed effects upon still later life.

Ballantyne was able to determine important relations of antenatal pathology to no less than seventeen departments of science (see his figure 3, page 18). Of the considerations in Taruffi's *Storia della teratologia* would come an application, and the further development in studies of the idiot types with the methods available to modern research. For example, the microscopy of all types of terata, described in chapters 14–30 of book 3 of Ballantyne's volume on the Embryo would get a new importance if proper histological studies were carried out. But withal, the teratologist would be studying this material from the standpoint of teratology and tissue mechanisms, and the fate of the feeble-minded as such would not be visibly altered for the better in a long period of years.

The *pathologist* might see not only the importance of antenatal pathology in the direction of monstrosities, but he might be greatly interested in what Ballantyne has termed the intrusion of the antenatal factor in neonatal disease as shown by instances of intracranial traumatism and intranatal infections (ophthalmia neonatorum, etc.). The pathologist would also be interested in the neonatal infections, such as sepsis neonatorum, as also very particularly in what Ballantyne has called the disturbed antenatal readjustments, such as icterus neonatorum, and the like. Here again the interest in the anatomy of the feeble-minded would be an interest derived *ab extra*. The pathologist must go to the specialist in feeble-mindedness for his material and carry his interest to that material. Hence from the pathological side it can hardly be hoped that there will be a tremendous flow of new work on this topic.

Again, the *embryologist* must be interested in the subject, as is clear throughout both volumes of Ballantyne's work; but the embryologist has so far shown little interest in what has sometimes been termed "late" embryology, confining his attention to the plentiful and unsolved problems of the earlier months. Hence what happens to the hypoplastic organ in the *viable* victim of feeble-mindedness is of less immediate interest to the embryologist by reason of the embryologist's comparative ignorance of late embryology

in general and hence of the appearances in organs sufficiently developed to permit their bearers to live.

It might be thought that the *physiologist* would take a tremendous interest in a number of aspects of feeble-mindedness since he would perhaps be able to find the differential effects of imperfect glands of internal secretion and a variety of simplified phenomena of nervous and circulatory reactions. On the whole, however, the physiologist probably feels that his knowledge of these matters in laboratory animals remains too tenuous to permit carrying the standard far afield in feeble-mindedness.

The *zoölogist* and even the botanist of course have the greatest interest in the germ cells, their development and interferences with their development. In various writers one discovers tendencies to the thought that there is a pathology of the germ plasm which at first sight spoils the simplicity of the Weismannian doctrines about the immortality and comparative immutability of the germ plasm. The interest in eugenics has fortified this interest, and no doubt all the germ cell biologists as well as the eugenists have fully in mind the value of studies in the ancestry and familial traits of the feeble-minded. Nevertheless these interests have not crystallized into a theory or plan of attack as to feeble-mindedness.

Like the child in Kipling, each science or art above mentioned has mysterious errands of its own; hence it seems likely that the workers in feeble-mindedness themselves must organize their own researches. Where then should research in feeble-mindedness begin? There is no lack of interest in the education of the feeble-minded. There is no lack of interest in various forms of social service, whether it takes shape as help for the individual, aid to the public purse, or an attempt to safeguard society. There is no lack of interest in heredity and eugenics. There is no lack of interest in the general administrative problem which offers one of the most productive regions for the administrator in the whole field of public service. There is no lack of interest in applied psychology as it has culminated in such mental tests as those of Binet, de Sanctis, Healy, Terman, and Yerkes. Little, however, has ever been said in favor of a consistent attack on the anatomy and physiology of the feeble-minded.

The present researches form a comparatively modest introduction to that highly desirable attack upon the physical aspects of feeble-mindedness which have been so inconceivably neglected in the past. We feel that it is wise to concentrate attention upon brain anatomy for the present, despite the fact that the ultimate value of physiological work, notably in the field of the glands of internal secretion may be immeasurably greater. However, in a number of fields of neuropathological and psychiatric research, we have found that much time can be saved if the physiologist and clinician can have the advantage

of knowing whether they deal on the one hand with entirely abnormal brains or on the other hand with relatively normal ones. This dichotomy of the material is rather apt to leave one with three groups of material, — a) material with gross lesions of an obvious and striking nature; b) material with lesions of a doubtful and questionable character, and c) material without obvious evidence of disease. The worker, whether he deal with insanity, epilepsy, criminal anthropology or any other major field touching the nervous system, finds it convenient to utilize various fundamental studies in the two limiting groups in the series, viz., the group of cases with obvious gross lesions and the group of material with no obvious lesions. He must leave the intermediate or non-interpretable group on one side at the beginning of his research.

The topic of feeble-mindedness is rendered difficult by the fact that the observer apparently cannot compare abnormal material with normal looking material just by reason of the absence of any normal looking material. At least an observer like Tredgold remarks that he has never "yet seen the brain of an idiot, a low or even medium grade imbecile which could be regarded as normal upon careful naked-eye examination" (of course it will be noted that Tredgold does not here speak of the imbeciles of higher grade and of the feeble-minded proper). It is safe to say that from the literature one cannot for the present assert whether or not the brains of imbeciles of higher grade, of the feeble-minded proper or so-called morons, or of the dullards or simple-minded persons who grade somewhat higher than the former, have normal looking brains. Beyond question, however, most workers distinguish at least roughly between the idiots and imbeciles of lower grade who are virtually bound to show obvious brain lesions, and the higher grades of feeble-minded, who may or may not show such lesions. In either case there is a tendency to the belief that amongst the higher grades will be found persons whose feeble-mindedness tends toward functionality as a limit. There is a tendency to the belief that the higher grades of feeble-minded are persons whose brains are fairly well developed in the sense of having a full complement of cells like their normal brethren, but whose cells do not for some reason work properly or have not, for some reason, developed their full panoply of processes. That there is a group of feeble-minded subjects that in a sense correspond to idiopathic epileptics or to the so-called functional psychopaths (for example, victims of manic depressive psychosis of modern conception), or like the delinquents whose brains are working, as it were, perversely, without structural basis for the perversity, amounts even to a working hypothesis with many observers. Upon this working hypothesis is founded a number of conceptions as to the educability and comparatively good prognosis of certain feeble-minded subjects "under proper conditions" or with an "improved environment." Whether there is an environmental group

of feeble-minded subjects, whether there is, as it were, an idiopathic or functional group of these cases, is an open question. Just as we suspect that there are frank psychoses which have their bases not in structural brain disorder but in exogenous factors working from outside the brain, so we may theoretically conceive that there are feeble-minded subjects in the same logical group. However, in a general way, the concept of "discords played on a good instrument" is not a concept which appears to have a wide scope in feeble-mindedness.

The literature does not lack work of a systematic and comparative nature upon idiocy. One has only to remember the work of Hammarberg above noted. The literature lacks consistent studies of feeble-mindedness of higher grade from the anatomical and histological points of view. This task should be one of the major ones of the present undertaking. Hammarberg's work was one of the first pieces of work not only in the anatomy and histology of feeble-mindedness but in the topographical histology of the nervous system. The topographical histology of the nervous system has only been thoroughly staked out within the present century. The idea of the brain's differential topography doubtless lay completely in the minds of such workers as Bevan Lewis, Betz, Meynert, Cajal and Nissl in the nineteenth century. Early in the present century, systematic works like those of Campbell, Brodmann and Cajal began to appear and to have currency. These works on topographical histology were supported by such brain anatomists as Elliot Smith and Ariens Kappers, as well as by the comparative anatomist, Edinger. The idea of cerebral cortex mapping, of a kind of cartography of the brain, has now obtained a firm foothold in neurology and neuropathology. It must, however, be accredited to the science of feeble-mindedness that the lamented Hammarberg was one of the first histologists who saw the importance of such cortex mapping and began his work upon the material of idiocy. To be sure it will be many years before a properly equipped institute carries out the inchoate aims of Hammarberg and the aims which we can all now so clearly see when we associate in conception the material of feeble-mindedness with the modern differential work on cortex structure.

One of the most fruitful distinctions in feeble-mindedness of the present day is that of Tredgold, who, seeing the inadequacy of the distinction of the feeble-minded into congenital and acquired cases has replaced this dichotomy with a new and different one, namely, with a division into what he calls primary and secondary amentia.

The primary aments are victims of what is sometimes termed "germinal blight," whereas the secondary aments are victims of some cause working from outside the brain. The primary ament, according to Tredgold, has cells with an intrinsic vital deficiency,—cells which are unable to develop. The secondary ament is the victim of arrest, due to

some external cause. One might say that the cells of the ament, if this distinction of Tredgold can be upheld, have "run down" or ceased to develop at a certain point, whereas the cells of the secondary ament have not run down of themselves, but have run counter to some agent; that is, the cells have not ceased to develop, they have been stopped. The distinction reminds one of the simple nomenclature apparently introduced into neurology by Moebius, namely, the distinction between cases of endogenous and cases of exogenous origin. One deals, as it were, with a plastic impotence, an agenesia, in the case of the primary ament; one deals with a sort of plastic arrest or aplasia in the case of the secondary ament.

The value of this distinction of Tredgold's is that the older heterogeneous anatomical classifications of the feeble-minded, such as were, for example, available to W. W. Ireland in his book on the "Mental Affections of Children" can be supplanted by a simpler classification with a number of new research possibilities. Ireland, for instance, speaks of genetous idiocy, namely, idiocy in which the disease condition which entails deficiency of mind is complete before birth, and in which accordingly the presumption of the hereditary connection is stronger than in other forms. Another chapter deals with microcephalics, a third with hydrocephalics, a fourth with eclampsic idiots, a fifth and sixth with epileptic and paralytic idiots, and further chapters with traumatic, inflammatory, sclerotic, syphilitic and cretinistic idiots, and the last chapter with what Ireland terms idiocy by deprivation (namely, that condition of mind in which a child remains who is deprived of two or more of the principal senses).

According to Tredgold a great number of the intrauterine causes of feeble-mindedness are, as it were, equally exogenous to the feeble-mindedness as would be a cause operating early after birth. The antenatal and neonatal pathology of feeble-mindedness would have to be separated into a congenital and acquired group forthwith, unless we adopt Tredgold's distinction and consider that numerous antenatal causes, such as foetal sepsis, foetal syphilis, and the like are just as secondary in their effects as would be these conditions in the neonatal period. Tredgold accordingly distinguishes an intrinsic from an extrinsic group and would probably subscribe to Moebius' terms "endogenous" and "exogenous" as equivalents of his own. In his original discussion of amentia in Mott's Archives in 1903, he had already practically distinguished the intrinsic forms as due to the condition of the germ plasm and the extrinsic forms as due to the environment, which environment he divided into antenatal, intranatal and postnatal. But in his textbook Tredgold states that the real question is as to the respective influences exerted by heredity and by environment and proposes that the terms "congenital" and "acquired" be given up. Tredgold defines extrinsic causes as any factors of the environment which are cap-

able of prejudicially affecting the brain development of the offspring after conception has taken place, whether these factors be intra or extra-uterine. Amentia due to such causes, Tredgold terms extrinsic or secondary amentia.

Tredgold's employment of the term "hereditary" is possibly somewhat special to him. Primary amentia Tredgold regards as not "due to absence or suppression of some specific germ determinant" such as some Mendelians assert, but "as resulting from a diminished germinal vitality in consequence of which development tends to be incomplete." Inheritance takes the form of the "neuropathic diathesis or innate predisposition to neurotic imperfection." As to the origin of the germinal impairments that lie at the foundation of the intrinsic or primary group of Tredgold, we have a number of possibilities. The Royal Commission on Feeble-mindedness decided that "both on the ground of fact and of theory, there is the highest degree of probability that feeble-mindedness is usually *spontaneous* in origin, that is, not due to influences acting on the parent — and tends strongly to be inherited." Tredgold regards this as a confession of ignorance. He, however, looks upon the hypothesis of Davenport that "feeble-mindedness is not a new variation, but a perpetuation of strains defective from the beginning" as not tenable. Tredgold regards the germinal variations in the parents of the feeble-minded as pathological variations, as a vitiation and not spontaneous. He regards this vitiation as primarily due to the action of the environment, quoting the work of Paul on lead poisoning, the work of Féré on the effect of alcohol on incubating eggs, the more recent work of Stockard upon guinea pigs and other similar work. Not only may the germ cells be poisoned, but they may be altered by a variety of physical conditions, such as temperature and non-toxic chemical agents. Whether or not Tredgold's conception of the causes of what he has termed germinal blight are as he thinks environmental, there can be no doubt that it is extremely valuable to separate out all definitely exogenous cases from a residue whose cause may be left undefined.

What now can we see in the brains of primary as opposed to secondary aments? In the secondary types of feeble-mindedness, we shall often see effects of inflammation, appearances like that of porencephaly, hydrocephalus, and the like, which must appeal to us as flowing from causes operating from without and indicating no essential vital deficiency or vitiation of germ plasm, and we shall be greatly interested to determine the nature of these exogenous processes and the quality and extent of their effects upon the brain map. In the light of these irregularly deficient brains we should, under ideal conditions, be immensely interested to learn whether the mental states of the bearers of these brains also show functional cut-outs and losses to correspond with the irregular defects of the brain lesion. A tremendous number of neurological problems will be settled

and a deep vista of new problems can be predicted. Moreover, we should learn much by extended study of these secondary cases from the standpoint of what is termed in the German "Korrekturbildung." We shall namely be interested in discovering what effects may be wrought by the lack of structure A upon the condition of structure B which, under normal conditions, grows in structural and functional relation to A.

But suppose there be no demonstrable exogenous processes and no basis for supposing an exogenous process in a given case. What now will be found in the brain?

The literary sources of information from which to answer this question are not numerous. We must first resort to Bourneville's volumes on Researches in Epilepsy, Hysteria and Idiocy, published in the form of Reports from the Bicêtre, beginning in the year 1881. These reports contain numerous cases reported as fully as the state of science permitted. The majority of the autopsy reports in the earlier years deal with epileptics. Numerous remarkable cases of tuberous sclerosis (sometimes called Bourneville's Disease) are described and photographed. The majority of these cases of tuberous sclerosis were victims of epilepsy or of convulsions in some form. Numerous reports are scattered through the series dealing with myxedematous idiocy. Through the eighties Bourneville's reports contained few instances of case reports in which convulsions were not prominent. In the nineties began to appear more numerous reports of idiocy and epilepsy without convulsions. Special studies of hydrocephalus, porencephaly and microcephaly appear, and the term "symptomatic idiocy" is frequently used in connection with such cases.

In 1891 Bourneville presents in his 11th volume an anatomical classification of idiocy (communicated at the International Congress of Mental Medicine in 1889) which classification has 8 chief heads, as follows: —

Idiocy symptomatic of hydrocephalus; of microcephalus; of arrest of convolutional development; of congenital malformation of the brain (porencephaly, absence of corpus callosum, etc.); idiocy symptomatic of hypertrophic or tuberous sclerosis; of atrophic sclerosis (A, of one or both hemispheres, B, of one brain lobe, C, of isolated gyri, D, of sclérose chagriné du cerveau); idiocy symptomatic of chronic meningitis or meningoencephalitis; and finally, idiocy with pachydermic cachexia (myxedematous idiocy connected with absence of the thyroid gland). It can readily be seen how much of this classification, which is based upon fifteen years of work at the Salpêtrière and at the Bicêtre, has relation to those aments whom Tredgold would readily call secondary aments. Bourneville and his collaborators have published excellent photographs of many of the cases in this series of volumes. From time to time, histological descriptions of a relatively elaborate nature accompany the reports and deal with questions of neuroglia prolifera-

tions and the like in quite the modern manner, which is the more remarkable since much of the work was done before the vogue of neuroglia studies begun by the publication of Weigert's book on Neuroglia in 1895.

The reports of the nineties are filled especially with accounts of idiocy symptomatic of atrophic sclerosis and of chronic meningitis. Reports upon congenital idiocy are on the whole infrequent in Bourneville's volumes. Such a case published in volume 13, 1893, by Bourneville and Dauriac was, for example, a congenital epileptic idiot, which was almost completely asphyxiated at birth, began to walk at 8 and completed dentition at 10. This idiot had had convulsions at 8 months followed by incomplete paralysis of the right side. Contractures of all limbs with athetotic movements had supervened. Double craniectomy was performed for therapeutic purposes in the thirteenth year. The autopsy showed, besides the effects of the operation, a cerebral atrophy (weight 855 grams), or as Bourneville says, the autopsy findings may perhaps better be said to have confirmed the diagnosis "arrest of brain development" made during the patient's life. There were no areas of sclerosis or induration and this fact is taken by Bourneville to corroborate the clinical evidence as to the absence of any severe convulsions. There were, however, certain leathery appearances in some gyri, notably in the left parietal and frontal regions and in the right frontal and temporal sphenoidal regions.

From such a description and from Bourneville's own remark as to the possible diagnosis of cerebral atrophy, it can readily be seen that such a case very possibly belongs in the group of secondary aments of Tredgold, although the condition may well have been congenital in the usual acceptance of that term.

In 1895 Bourneville and LeNoir published an example of so-called complete congenital idiocy with paraplegia, contracture and deformity of feet. The brain of this case is described by Bourneville as having been reduced to the greatest simplicity, "virtually down to the elementary convolutions." Although these convolutions are in general voluminous, even strikingly voluminous, and the sulci are of a proper depth, annectant convolutions are almost completely lacking. Plates are presented of this case which died at 18.

In 1896 Bourneville and Ruel present another case of "complete idiocy," probably congenital. The brain showed neither meningitis nor focal lesions.

In 1897 Bourneville and LeNoir again published a case of congenital idiocy due to arrest of development, and state that the brain reveals no macroscopic lesion. Nevertheless its morphology is rudimentary and the arrangement of the convolutions is in many places abnormal. These might serve as examples of the few available reports concerning cases of so-called developmental arrest to be found in Bourneville's series.

Although he terms these cases congenital and speaks of some of them as victims of developmental arrest, they seem on the whole to stand nearest to the cases which Tredgold would be inclined to term primary aments. The number of cases of myxedematous idiocy and of various forms of so-called symptomatic idiocy with atrophic sclerosis and meningitis continue far to outnumber the cases of congenital nature. In passing one can only comment with admiration upon the breadth of Bourneville's general plan of attack on his problem, combining as it does the clinical, therapeutic and anatomical ideals.

We shall now naturally turn to Hammarberg for evidence as to the essential nature of these two groups of cases, whether on the one hand we adhere to the older distinctions of congenital and acquired cases, or adopt the more modern distinction of primary and secondary amentia proposed by Tredgold.

Hammarberg's monograph was published in Upsala in 1895, edited by Henschen, after the death of the author from appendicitis. His work appears to have been done a few years after his graduation in medicine and to represent a comparatively brief period of intensive endeavor. His report deals with 9 cases. He believed that he could prove in all cases that the psychic defect could be connected with defective nerve cells in the cortex. The cortical deficiency he considered to be due either to a standstill in development at some antenatal or early neonatal stage, in consequence of which but a small number of cells were permitted to arrive at high development. He admitted the possibility that cells might be destroyed during the process of mal-development.

In some cases development had been checked in small regions by agents working in a limited and local manner, but in such wise that the total development of the cortex had been unfavorably influenced. If the check in development occurred in the latter stage of foetal life, psychic development in the subject became impossible and these cases are grouped as idiots, "*blödsinnig*", in group A. Since the inhibiting factor acted unequally in different parts of the developing brain, a variety of disorders in the cranial nerves in locomotor capacity and in sensibility, such as were found in many cases, were explicable.

In a second group of cases the cortex had not been permitted to arrive at a degree of development more than one normal for the first years of life. These are cases which Hammarberg groups as markedly weak-minded (*in hohem grade Schwachsinnige*). Such cases also exhibited the same irregular cranial motor and sensory disorders.

A third group of cases is a group in which the inhibitory factor is thought to occur during the first year of life and to affect only a small region of the brain. The rest of the brain is regarded as developing properly in all directions, except that the number of cells seems to remain smaller than normal. The psychic result is that the patient is

inactive and less developed than a normal person of the same age. These are cases classified under B 2, as moderately and slightly weakminded (*mässig und in geringem grade Schwachsinnige*). Similar peripheral disorders are found in these cases also.

The idiots of Hammarberg's series number 4,

The markedly weakminded, 2,

The moderately and slightly weakminded, 3.

Although there are a number of drawings of gross brains in plates 6 and 7 of Hammarberg's monograph, the chief direction of Hammarberg's research is microscopic. Excellent drawings to scale of preparations from various areas of the cortex, stained by methylene blue, are presented in plates 1 to 5. Plates 1, 2 and 3 deal with the normal cortex (since it must be remembered that Hammarberg's work antedated the cerebral topography of late years) and deal with superior and inferior frontal gyri, with the precentral gyrus, the superior temporal, the superior and inferior parietal and superior occipital gyri, the central lobe, hippocampal gyrus, the fascia dentata, cornu ammonis, fascia cinerea, the gyrus cinguli and the gyrus centralis superior.

The pathological plates are 4 and 5 and contain 15 drawings to scale of a number of the above mentioned areas. The whole work is but a torso of what Hammarberg would doubtless have accomplished had he lived.

A number of Hammarberg's observations as to the microscopy of feeble-mindedness exhibit a very modern insight. For example, he dismisses the frequently expressed notion that the pericellular and perivascular spaces are enlarged about the brain cells of idiots, whether in consequence of lymphatic stasis or of cellular atrophy. He regards these features as shrinkage processes, finding them to occur only in material which had at some stage been placed in alcohol of marked concentration, and finding similar changes to occur in normal persons. These findings, then, are dismissed by Hammarberg as artefacts, and it is probable that all modern workers will agree with him.

A second statement to be found in the literature preceding Hammarberg and to some extent since his day is that the brain cells of the cortex in idiocy present a disorderly or imperfect arrangement, so that the apical processes lie at right angles to their normal direction or obliquely. Hammarberg discovered that identical appearances might be found in entirely normal material, noting especially that in the inferior frontal gyrus and the hippocampal gyrus such apparent disorder in the orientation of cells is normal.

A third question of contention in the literature deals with the occurrence of cellular atrophy, vacuole formation and pigmentary degeneration, but such changes as these were found by Hammarberg in but one of his 9 cases, and he notes that undeveloped cells have

frequently been taken for atrophic ones, especially if at the same time an imperfect technique has produced the artefact of dilated pericellular spaces.

Hammarberg accordingly dismisses the idea that the nerve cells of the idiot and imbecile do not fill enough space in the cerebral cortex in which they are embedded, that they are especially subject to irregular orientation therein, and that they are necessarily subject to atrophy, vacuole formation or pigmentary change.

Hammarberg's conclusions then deal with four cases of idiocy, namely, subjects deficient in all the higher psychic functions and incapable of psychic development. In three of these cases the greater part of the cortex was in a stage of development normally found in the last half of intra-uterine life. In a fourth case development had, according to Hammarberg, progressed farther and had reached a stage found normally in the first year of life; but in this case a process had occurred which had reduced development back to the same stage as in the other three cases.

The second group of cases, two in number, is a group of markedly weak-minded subjects, whose mental life corresponds to that of normal individuals of one to five years of age. Their cortex was found, according to Hammarberg, to be in a stage of development found in normal individuals during the same years.

The three cases of the group of moderately or slightly weak-minded are cases in which the mental functions are sluggish and somewhat less developed than in normal individuals of the same age. Such subjects are capable of a certain amount of education. Their degree of development, from a mental standpoint, might readily be compared to any special stage of development in normal individuals. According to Hammarberg, the number of nerve cells in the greater part of the cortex is much less than normal and the remarkable feature of the general brain situation is that in one particular region the cortex will be found to be in a stage of development normally appearing in the very first year of life. Here then a number of claims appear which would be well worth substantiating by extensive studies.

The most elaborate recent statement concerning feeble-mindedness is that by Tredgold in his book on "Mental Deficiency". The ideas are largely based upon special work as published in Mott's Archives of Neurology, Volume 2, 1903, carried out in the Claybury Pathological Laboratory during two years' tenure of the London County Council Research Scholarship in Insanity and Neuropathology. Mention has been made above of Tredgold's conception of primary and secondary aments. He regards the essential basis of primary amentia as cellular. Such gross conditions as porencephaly, hydrocephalus, microgyria, hemiatrophy, and the like, are of course frequently associated with amentia, but they are, according to Tredgold, accidental associations therewith. "The

essential basis of amentia is an imperfect or arrested development of the cerebral neurones." Tredgold calls attention to numerical deficiency in cells (compare Hammarberg's work), to irregular arrangement of cells and to imperfect development of cells, giving rise to the frequent appearance of certain cells first described by Bevan Lewis, or to some still more ill-developed cells which correspond with early neuroblasts. Tredgold states that the amount of change discoverable by the microscope is directly proportionate to the degree of mental deficiency present during life. Tredgold also ascribes importance to pigmentation, believing that it is an indication of defective metabolism in which anabolic processes cannot keep pace with the catabolic.

Hammarberg and Tredgold are accordingly in apparent discord as to the significance of irregular arrangement of nerve cells. Tredgold believes that his own experience as well as that of several others makes it clear that an irregular and haphazard arrangement of cortical cells is very characteristic of the condition. He states that such irregularities are found often where there is no accompanying sclerosis. This problem of the irregular arrangement of nerve cells and its significance accordingly remains a problem in the minds of many workers. Doubtless Tredgold would agree with Hammarberg as to the non-characteristic nature of the pigmentation found.

As to two points, Hammarberg and Tredgold are then in comparative agreement, namely, that numerical deficiency in nerve cells is a major feature in brains of feeble-mindedness and that the cellular appearances indicate imperfect development. If we consider the problem from the point of view of these two authors, accordingly, we must spend a maximum of attention on the number of cells and on the qualitative appearances therein.

We cannot pretend at this time to deal with the literature of the anatomy of feeble-mindedness with any completeness, although we have had the advantage of the relatively complete index of the literature of feeble-mindedness possessed by the Waverley School, from which we have abstracted over eight hundred references which deal pretty specifically with anatomical problems. We present below a selection from these anatomical references, having chosen those that relate more especially to the types of case considered in the first series of ten cases. The outstanding work of Bourneville and of Hammarberg as above mentioned, and the systematic treatment of Tredgold, do not by any means exhaust the anatomical interests of feeble-mindedness as presented in readily accessible literature. A book of strongly anatomical trend is that of W. W. Ireland called "Mental Affections of Children", wherein are given a number of points of view of permanent value. Ireland's classification has been given in brief above in the discussion of Tredgold's point of view.

Below we shall consider some American work in the field, before which it may be thought desirable to consider the status of the anatomy of feeble-mindedness as presented at the thirteenth international medical congress held in Paris in 1900. The eighth volume of the *Comptes Rendus* is devoted to psychiatry. There were three special questions proposed to the psychiatrists at this congress, one of which was the question of the pathological anatomy of idiocy. Reports by Mierzejewski, of St. Petersburg, of Shuttleworth and Fletcher-Beach of England, and of Bourneville, were presented, with a special contribution to histopathology by Philippe and Oberthür.

Mierzejewski considered that Bourneville's classification based upon coarse changes in the brain might well correspond to practical needs, but that a histological classification based upon special studies and upon exact embryological conceptions was sure to develop in the future. Mierzejewski considered that the basis of every anatomical lesion in the idiot's brain is a developmental deviation in the nerve tissue. Its origin must be sought in embryonic life or in disease occurring in earliest infancy. There could be no question of any true arrest of development without its morphological and histological basis in the entire brain. There could be determined, however, a true arrest of development in certain regions as indicated by the presence of neuroblasts. Mierzejewski went on to describe a particular group of cases, namely: those in which the white substance of the cerebral hemispheres is well developed but the gray matter of the cortex is distinguished by appearing in enormous and disproportionate amount. It was true that such brains belonging to microcephalic or demi-microcephalic subjects as a rule showed small convolutions (microgyria), but there were cases of this disproportionate development of the cortex in which there was no microgyria. Mierzejewski had published the first case of this nature in the *Comptes Rendus* of the international congress at Geneva in 1877.

The Mierzejewski type of idiot brain is characterized by a fairly developed centrum semiovale, an enormous distension of the ventricles, with the cerebral hemispheres transformed into a species of thin-walled vessel, 15 or 16 mm. thick. In such extreme examples as this, there is always microcephaly as well as microgyria, but there are other cases in which the white substance of the hemispheres is not so shallow and in which microgyria is absent. In such cases, finer methods will determine a lack or insufficient development of transverse intracortical medullated fibres. In von Monakow's case, there were neither any tangential fibres nor any striations of Vicq-d'Azyr. In other cases these structures were more or less well developed.

The situation was identical with the short and long subcortical association fibres, absent in certain examples, more or less developed in certain others. The radial bundles also varied in their development in these cases.

The gray matter presented at first sight the appearance of making up for the insufficiency of the white, sometimes presenting all its characteristic layers with perfect distinctness; in other cases presenting irregularity of arrangement.

The distinguishing feature of these hemispheres was the interpolation of a layer between the centrum semiovale and the cortex, of an intermediary strip of the so-called neuroblasts; or in certain cases, a layer of cells resembling those of the lower layers of the cortex, but irregularly arranged. In one case there had been interposed between the new layer and the overlying cortex a separate strip of white matter. This condition of affairs is called heterotopia of the gray matter. Although this particular form of heterotopia is diffuse, it does not resemble that more frequent form of heterotopia in which there are islets of ganglion cells scattered through the white matter. The microcephalic cases of microgyria show the interpolated layer to be formed of "neuroblasts." The demi-microcephalics have cells in the interpolated layer which resemble the so-called polymorphous cells of the undermost layer of the normal cortex.

This Mierzejewski type of microcephaly is accordingly distinguished from the ordinary microcephalic brain in that the proportions between gray and white matter, more or less well observed in the usual case, are not preserved in the Mierzejewski types. The demi-microcephalics according to Mierzejewski resemble the normal more closely in that the arrest of development on the part of the white matter is of slighter degree and is accompanied by a diffuse subcortical heterotopia of gray matter. But the principle is identical in both types of case.

Mierzejewski goes on to describe in more detail certain microscopic findings in a fresh case of the disease, and then sums up somewhat as follows: Idiocy may in certain instances accompany a condition in which the gray matter is extremely rich and in which there is an abundance of nerve cells. In these cases the commissural system of the convolutions is arrested in development so that there are not a sufficient number of paths of intercommunication and there is a disharmonious development of the different nervous elements. In the central nervous system, quantity alone does not count, but quality of elements and quality in their reciprocal combinations are the things that count. The white matter is nothing but a mass of prolongations of the nerve cells; accordingly richness of the dendritic branchings and of axis-cylinders of cells is the condition which most favors the plentiful development of white matter; and when these ramifications are few in number, the development of the white matter is insufficient. One of the chief conditions for irregular processes would then appear to be the multiplication and broad expanse of the connections of the pyramidal cells. Mierzejewski attributes to Dejerine the idea that intellectual supremacy seems to be the result, not so much of the number of cells,

as of the multiplicity and extent of their inter-connections. The idiot may have cells enough though these are deprived of their proper branchings. Mierzejewski throws out the suggestion that some of the neuroblasts lying below the normal-looking cortex may now and then proceed to a further development, and thus explain the occasional notable amelioration of mental faculties found in idiots.

The report of Shuttleworth and Fletcher Beach presents a classification of the pathological anatomy of idiocy under three main headings: (a) CONGENITAL; (b) DEVELOPMENTAL; (c) ACQUIRED or ACCIDENTAL. Among the congenital cases Shuttleworth and Beach enumerate eight forms.

The *microcephalic* form contains cases with cerebral hemispheres shortened in such wise as to reveal the cerebellum viewed from above, with such hindrance of development during intrauterine life (probably between the third and fourth months of pregnancy) as to disturb the later growth of the hemispheres as well as the detailed development of those parts which had been already formed. It is perhaps the temporo-sphenoidal and occipital regions which suffer most (as to the occipital region, Cunningham and Telford-Smith are quoted). Microcephaly is probably not caused by the premature synostosis of the cranial sutures. On the other hand, the development of the brain is probably the determining factor as to the form of the cranium (H. A. Humphrey). Microscopically one finds simply rounded or oval cells or cells with but few dendrites.

A second form of congenital disease is *hydrocephalus*, both that due to antenatal and that due to postnatal conditions. According to Meynert, congenital hydrocephalus extends the lateral ventricles lengthwise, while acquired hydrocephalus stretches the ventricles vertically and transversely. Cases of Bourneville, Beach, and Alexander Hill are quoted.

A third form of congenital disease is *scaphocephaly*, a condition possibly due to a premature union of the sagittal suture with an exaggeration in the growth of the coronal and lambdoid sutures in such wise that the head is elongated from before backwards, and may sometimes increase in height. But, on the other hand, this condition may possibly be the result of an original elongation and narrowness of the cranium, such as may be found in the natives of New Caledonia, the New Hebrides, and the Carolines. Sir W. Turner is quoted to the effect that this cranial form is due to intrauterine causes, such as inflammation or injury of the mother during pregnancy. Scaphocephaly does not necessarily produce idiocy, and an approximation of this form of skull may be found in North American tribes due to artificial compression.

A fourth type of congenital disease is the *Mongolian* type, with its special bony, cutaneous, mucosal, and cardiac conditions. Brachycephaly, approximately circular

in circumference, with a tendency to parallelism of the parietal and occipital surfaces, is noted. The skull is thin. There is an anomalously short little finger with lateral incurving displacement of the terminal phalanx. The skin is coarse and scaly, the mucous membrane irritable, the tongue is long, marked with deep folds, due to hypertrophy of papillae. Cardiac lesions are cited from cases of Garrod and of Thompson. Wilmarth's work is quoted as to the brains, which are said to show a very small pons and medulla, as well as very thin vessels. Shuttleworth thinks that these Mongolian idiots are essentially unfinished children, and that their singular appearance is that of a phase of foetal life.

The fifth form of congenital case is the so-called *genetous* or congenital neuropathic form, the offspring of neurotic parents. These cases are said to show very early in life excessive irritability, insomnia, attention disorder, and loss of self control. Such subjects are said to show microgyria at autopsy.

The sixth type is the type of *amaurotic family idiocy* of Tay and Sachs.

The seventh form is that of *sporadic Cretinism.*

The eighth form is a form presenting *partial and local atrophies.* Examples are absence of corpus callosum, porencephaly, cerebellar aplasia, and the like.

In addition to congenital cases Shuttleworth and Beach then consider the developmental group, under which they consider eclamptics, epileptics, syphilitics (including juvenile paresis) and paralytics.

They consider that the lesions found in *eclamptic* cases associated with the severe convulsions of dentition are local hemorrhages and adherent membranes which are inconsistent with the normal nutrition of the gyri. As for the *epileptic* group, the work of Bevan Lewis, of Andriezen, and of Echeverria is quoted.

Syphilis, they consider, is not a common cause of idiocy, but juvenile general paresis they regard as commonly caused by syphilis. They state that since Clouston first described this latter disease, there have been about 100 observations published.

The majority of the *paralytic* group of the developmental cases are of postnatal origin. These cases are attributed to inflammation of the brain or the meninges.

In the third group of accidental or acquired cases, Shuttleworth and Beach consider three forms: traumatic, postfebrile, and sclerotic.

The *traumatic* cases are due to compression of the head during prolonged labor or to the forceps. The lesions are situated as a rule in the Rolandic region. Small hemorrhages occur which are followed by degeneration and sclerosis. In the cases of cerebral diplegia, the most frequent cause is a meningeal hemorrhage especially affecting the veins between the pia mater and dura mater in the longitudinal sinuses, in such wise that the hemorrhage in finding its way into the great fissure compresses the upper borders

of the two hemispheres. The opinion of Osler and of Jacobi is quoted: that certain of these cases are actually due to foetal meningoencephalitis. Intelligence need not be markedly affected despite the severity of the physical disease.

Under the heading of the *postfebrile* cases, Shuttleworth and Beach also take up the cases of so-called hypertrophy. The most frequent acute infections which bring about these postfebrile cases are smallpox, typhoid fever, and scarlet fever. Meningeal, neuroglia, and nerve cell changes are noted in different degrees. The relatively rare affection known as hypertrophy of the brain shows an increase of neuroglia and of the white matter, but the nutrition of the brain seems also to be affected. The brain looks anaemic on section and strikes one as having been under a certain pressure within the skull, showing flattened and compressed gyri with sulci effaced. The most markedly injured part of the brain is the white matter of the hemispheres. The head does not reach the size of the head in hydrocephalus, nor is the increase so marked in the temples as it is in the superciliary region. The hydrocephalic head is rounded; the skull in hypertrophy tends more to squareness. In hydrocephalus the distance between the eyes is increased; not so in hypertrophy.

The third type is that of the sclerotic brains, carefully studied by Bourneville. Wilmarth is quoted as finding in 500 autopsies no less than 96 cases. The tuberous form of sclerosis was found in 15 instances.

Bourneville presented his anatomical point of view under the following ten heads:

1. Meningitic idiocy.
2. Meningoencephalitic.
3. Developmental (simple arrest).
4. Atrophic sclerosis.
5. Hypertrophic or tuberous sclerosis.
6. Porencephalic.
7. Pseudoporencephalic.
8. Myxedematous.
9. Congenitally malformed.
10. Microcephalic.

This account of the general aspects of brain anatomy in the feeble-minded might be concluded by a brief reference to the American literature. Besides the allied but separate topic of amaurotic family idiocy or Tay-Sachs disease, not here considered, and various case reports presented largely from the aspect of being interesting as clinical neurological phenomena by Mills, Spiller, Pearce, and others, the American literature is

devoid of much systematic work except that of Wilmarth about to be considered. From Massachusetts, a few cases have been published by Bullard and one by Southard. An interesting attempt was made by Orton in his "Pathological Study of a Case of Hydrocephalus" to parallel the cortex mapping of the topographers (Campbell, Brodmann, and the others) by a similarly conceived study of a markedly hydrocephalic case. He showed how certain portions of the cortex normally sunken below the surface are, as it were, ballooned out to appear on the surface of the dilated brain. The kind of work there initiated by Orton should be continued and performed in a large series of cases, but such work, of both an intensive and extensive nature, requires the resources of a brain institute to execute.

The largest series of cases of feeble-mindedness as yet studied in America from the anatomical point of view is unquestionably the series reported by A. W. Wilmarth, formerly of Elwyn, Pa. This work is favorably commented upon in many publications on feeble-mindedness.

Wilmarth reported in 1890 on the examination of 100 brains of feeble-minded children. The following table shows the classification employed although it is not now possible to learn which cases were entered twice in the table.

No actual disease or imperfect development of the brain	25
Non-development in various forms	16
Degenerative changes in vessels, ganglionic cells, or medullary substance not constituting true sclerosis	15
Sclerosis or atrophy	12
Diffuse sclerotic change	7
Tuberous sclerosis	6
No actual disease or involved development of brain but hypertrophy of the skull	6
Hydrocephalus	5
Extensive adhesion of membranes from old meningitis	3
General cerebral atrophy	2
Acute softening, recent	2
Demi microcephalus	2
Brain above usual weight but convolutions large and simple	2
Infantile hemorrhage	1
Angiomatous condition of cerebral vessels with degenerative changes	1
Glioma with sclerosis	1
Porencephaly with non-development	1

It will be noted from this list that no less than 31 cases, or at any rate 25 cases, were not observed to show any evidence of actual disease of the brain or of imperfect development therein. These observations are probably the most decisive in the literature upon which to found the idea that the brain of a feeble-minded person may not show in the

gross any evidence of defect. It is well known that in the field of mental disease proper, commonly known as insanity, the opinion long prevailed that there was not necessarily anything grossly abnormal to be found in the brains. Upon the older observations was founded the idea of the functional nature of mental disease so long prevalent. It would have been equally easy to have founded a hypothesis as to the functional nature of feeble-mindedness upon such data as these of Wilmarth. In fact, there are, so far as I know, no more modern data upon which to make a new judgment. In the somewhat allied field of epilepsy, however, Thom and the writer have recently discovered a somewhat similar percentage of normal-looking brains if we confine attention to the gross appearances; namely, about 30 per cent. Our own first series to be presented below (Waverley Research Series Cases I–X) shows at least three cases whose brains might well be considered in the gross as of a normal appearance. Perhaps, then, the generalization which Wilmarth's figures might permit will attain objective value. Wilmarth does not describe further these interesting cases with normal-looking brains. He states that 34 of the 100 cases belong to the school department or were employed as aids in the asylum department, and that 66 of the cases were children belonging properly to the asylum department.

Wilmarth was struck by the comparatively large number of cases of actual cerebral disease in contrast with the relatively small number with imperfect development which seems to be the causative agent. There were, however, 16 cases of so-called non-development in various forms, which put together with two cases of overweight brain with large and simple convolutions, a case of porencephaly with non-development, and possibly two cases of demi microcephalus, make a fairly large total of cases of arrest of development. As against these 21 cases of developmental arrest may be placed 42 cases; namely, 12 cases of sclerosis and atrophy, 7 of diffuse sclerosis, 15 of degenerative changes not regarded as constituting sclerosis, 2 of cerebral atrophy, 6 of tuberous sclerosis. It appears then that, although it is not safe to say that there is a relatively small number of cases with imperfect development, there is a somewhat larger number of cases of actual sclerosis of the brain substance which may be safely regarded as due in some sense to progressive changes, or at least to changes subsequent to birth. How many of these sclerotic cases are merely complications of developmental arrest was of course not possible for Wilmarth to decide and indeed constitutes a problem of the greatest difficulty. Besides the cases of arrest and the cases of sclerosis with or without arrest, there are a few cases of more obviously acquired nature, namely, one of infantile hemorrhage, three of old meningitis, and two of softening (though these latter may well have been cases of complication having nothing to do with feeble-mindedness).

The case of angiomatous condition of cerebral vessels was one of Mongolian idiocy.

Wilmarth had five cases of Mongolian idiocy in his series. He regarded the brains as "of good size for imbecile brains." The pons and medulla were very small, weighing about ½ ounce in each instance, whereas the usual weight according to Wilmarth is nearly twice as much. He found the cerebral vessels inclined to be much thinner than in healthy brains, and was led to suspect from the defective nutrition and circulation of these children that the defective condition of the vessels was a general one. He laid down an interesting hypothesis in the following words: "From the small size of the pons and medulla in every instance, there seems to be a strong probability that the low nutrition, and possibly the other anatomical peculiarities of this group, may be due to the imperfect development or absence of certain cell groups in this region." The following extracts from Wilmarth's paper give further notions as to his conceptions:

"Probably the most frequent morbid condition met with is sclerosis in its various forms. The most destructive of these to the functional activity of the part involved is the so-called *sclérose tubérense*. It is usually seen on removing the membrane, as one or more areas of a white color and considerably harder in consistence than the surrounding tissue, slightly elevated above the level of the neighboring convolutions. It may be single but is usually multiple. It seems to be formed by a finely granular exudate, probably albuminous in character. If it occurs in the motor regions of the brain, the resulting paralysis is very complete, and if a large portion of the cortex is implicated, profound idiocy is liable to be the result."

"Another form of sclerosis, in direct contrast with that just described, is marked by shrunken tissue, the fibrous character of its structure, [*sic*] is more liable to be found in localized mass than in disseminated nodules, and is apparently less destructive to the function of the parts implicated unless it has reached an advanced stage."

"Non-development is found in several forms. A portion of the cortical substance may be thin, and instead of following the typical arrangement of the fully developed brain, form a number of irregular folds, which may be so small and numerous as to resemble a mass of angle worms. Again, the gyri may be of a normal size and appearance, but show a diminution in number, or absence of ganglionic cells in certain layers. Or, again, the convolutions may begin of normal size and development, but soon diminish and sink beneath the surface of the hemisphere, or perhaps entirely disappear, before acquiring near their normal length."

From the above all-too-hasty analysis of the literature of brain anatomy in the feeble-minded, we may suggest the following problems as facing us in the present situation.

1. There should be an attempt all over the world to swell *the number of properly reported cases* of feeble-mindedness *with autopsy*. If we speak of cases with suitable

histological studies alongside the clinical and anatomical observations, we shall shoot far over the mark if we concede that the literature contains 100 comparable cases — certainly a slender material from which to draw conclusions. Tredgold's interesting book, for example, is founded upon something like a dozen cases, among them epileptic and juvenile paretic cases. Hammarberg's work dealt with but nine cases. Many of Bourneville's cases are *curiosa*.

2. *Systematic* external *photography* and photography of the sectional brain should be freely used and reproduced. For in no other way can what is normal in the gross brain be established. The "normal" anatomists have little or no opportunity as a rule to lay down their own standards, using as they often do prison material, asylum material, and the like, and regarding "brain anomalies" with the same equanimity as anomalies in the liver.

3. *Total brain sections* may facilitate the just-mentioned task and are of especial value in marking off "secondary" from "primary" aments, through evidence afforded of special fiber-degenerations.

4. What may be called the "Mierzejewski effect" is worth particular attention, viz. the problem afforded by certain cases of disharmonious development of gray and white matter (gray in excess), in which the commissural system is thought to be deficient. Rich conscious endowment with poor mobilization might result in mild cases, if we carried the Mierzejewski idea to the limit.

5. From feeble-mindedness material we may hope to establish the truth or modified truth of the idea attributed by Mierzejewski to Dejerine, viz. that intellectual capacity depends more on cell interconnections than on cell numbers. The Dejerine argument is probably taken for granted by most workers nowadays but certainly needs proof and extension to details.

6. Hammarberg's idea that he could more or less approximately date the origin of many events of development in his cases requires further work. Such considerations as those of Donaldson *re* Laura Bridgman's brain are decisive here. Who knows what results bearing upon education would be obtained by exact ideas as to the chronology of normal cerebral development? The route to these observations may in part lie through feeble-mindedness material.

7. An exact definition in cerebral terms of "plastic impotence" (agenesia) and "plastic arrest" (aplasia) would help in many fields, especially perhaps in that of dementia praecox. Indeed strong arguments could be brought for the assertion that future psychiatry is to be founded upon a proper knowledge of feeble-mindedness.

8. The problem of the "normal-looking" brain in feeble-mindedness is intriguing.

Is there such a thing as "functional feeble-mindedness"? We speak of manic-depressive psychosis perhaps or of certain psychoneuroses as "discords played upon good instruments." Can the good instrument simply remain in its case, as it were, with resulting amentia?

9. A host of special problems in developmental mechanics, glandular dysfunction, disharmonious development of organs, heterotopia, dislocation of cells, reactive gliosis, satellitosis, premature pigmentation of cells, and the like remain, not to mention the problems of alcoholism and syphilis in parents and the operations of heredity working as it were *per se*.

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NOTE: — This bibliography is partial. It is based upon the entries in the card catalogue of the Massachusetts School for the Feeble-minded and contains those titles which specifically refer to the anatomy of the feeble-minded or articles which are known to contain anatomical material not indicated in their titles. To this fundamental list, which is indicated by Roman numerals and Arabic figures describing the place of articles in the Waverley collection, have been added further references called for by the present work. The bibliography is a working bibliography without pretensions to completeness, and has been arranged by years in such a manner that the history of the development of the subject is clearly shown. Future additions to this bibliography will be made, also by year numbers.

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II.

CLINICAL, ANATOMICAL, AND BRIEF HISTOLOGICAL DESCRIPTION OF TEN CASES OF FEEBLE-MINDEDNESS, WITH EIGHTY-FOUR PLATES (WAVERLEY RESEARCH SERIES, CASES I–X).

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We proceed to a condensed description of the findings in Cases I–X of the Waverley Research Series. For convenience we offer the following table, showing a number of facts about each case, chiefly of a catalogue nature:

Research Series number	Clinical Source number	Local Autopsy number	Harvard Series number	Photograph number	Sex	Actual Age	Assigned Mental Age	Height last taken	Brain Weight, grams	Brief designation
I	W. 2268	Taylor, 65	14.5	28	M	5	1—app.	82	400?	Microcephaly
II	W. 1437	Taylor, 21	14.6	26	M	20.5	1—app.	subn.	620	"
III	D. 14550	D. 1279	12.20	24	M	45	7 app.	126	610	"
IV	D. 16282	D. 1517	12.21	23	F	62	12±app.	143	1340	Moron or subnormal
V	D. 14779	D. 1413	13.13	1413	M	16	12±app.	168	1435	Subnormal, dementia praecox
VI	W. 1453	Canavan, 3	13.47	75	M	26	2 Binet	158	1130	Idiot
VII	W. 1574, 1618	Canavan, 8	14.13	78	F°	25	5(2—)3 Binet	146	1270	Imbecile
VIII		Magrath, 3917	12.22	1	M	36	12±app.	179	1340	Murderer
IX	W. 808 Burbank 9760	S.B.I. 14.22	14.69	14.69	M	39	7 Binet	178	1620	Imbecile
X	W. 971	S.B.I. 14.69	15.2	15.2	M	37	2.4 Binet	144	1450	Imbecile

W. = Waverley (Massachusetts School for Feeble-minded). Burbank = Burbank Hospital, Fitchburg. Canavan = private autopsy series, M. M. Canavan. D. = Danvers State Hospital. Magrath = Medical Examiner's series, G. B. Magrath. S.B.I. = series since establishment of Massachusetts State Board of Insanity, Pathological Service, July 1, 1914. Taylor = private autopsy series, E. W. Taylor.

The items of our description call for little comment. They are in general:

a. Clinical Findings
b. Autopsy Findings
c. Special Description of Brain
d. Partial Microscopic Description
e. Anatomical and Histological Summary.

As to *a. Clinical Findings:* These have been arranged so far as possible to follow a scheme employed at the Massachusetts School for the Feeble-minded and originated by Dr. W. E. Fernald. The headings are ten in number, as follows:

1. Physical Examination.
2. Family History.
3. Personal and Developmental History.
4. History of School Progress.
5. School Examinations.
6. Practical Knowledge.
7. Economic Efficiency.
8. Social History and Reactions.
9. Moral Reactions.
10. Psychological Tests.

Following the items thus arranged are notes, usually brief, concerning the institutional history, if any, of the patient.

As to *b. Autopsy Findings:* These are limited to the gross anatomical findings of the examiner as made on the autopsy table. Their results are more systematically given in table form in Article III.

As to *c. Special Description of Brain:* The data are founded upon examination, as a rule, subsequent to the autopsy and to the preservation of the brain, which has been in all cases in 10% formaldehyde solution, in many cases for relatively long periods, which are obvious from the dates included in the descriptions. As a rule, the special brain description has had the advantage of comparison of the brain specimen itself with the photographs, systematically taken, of the brain before and after stripping the pia mater. These descriptions are largely the product of Dr. Taft, who has personally stripped each brain of the pia mater, preserving the pia mater in certain cases where there was question of important lesion therein. The nomenclature is, as a rule, self-explanatory and follows largely the nomenclature of Quain's *Anatomy.*

As to *d. Partial Microscopic Examination:* It must be insisted that this is really but partial and has no pretensions to the completeness which the resources of a modern laboratory will eventually command. Nevertheless, we have resorted in each instance to total brain sections stained by the Weigert myelin sheath method in our estimates of the fibre content of the brain. The resulting estimate is, as a rule, entirely qualitative. But it may be questioned whether it is possible at this time to make more than a qualitative estimate of fibre contents. The total brain sections stained by the Weigert method have been of value in the estimates of the depth of the corpus callosum, as well as for the purpose of discovering special periods of degeneration or faulty development of fibre systems.

We have, also, employed staining methods for the study of cortical architecture,

employing as a rule cresyl-violet in place of thionin and methylen blue. This sharp nuclear stain has permitted us in most cases to make a profitable study of the cortical lamination, as well as to bring out the exudate about vessels where exudate is present. As will be emphasized in Article III, the existence of exudate in more cases than had been at first suspected is probably of importance from the genetic standpoint, since syphilis or some kindred chronic inflammatory condition may be suspected in cases with such exudate. Again, we have been able to observe rod cells in certain cases, which cells again tend to indicate a more progressive condition than has been considered typical in cases of feeble-mindedness. In suitable cases, we intend to make special topographical studies of cortical laminations. This we have in hand in chosen instances, and the resulting descriptions are intended to appear in later articles in this series. For the present, as will be evident from Article III, we have limited our microscopy to the question of exudate, rod cells, and the like, on the one hand, and to qualitative estimates of cortex lamination, fibre content, on the other.

As to *e. Anatomical and Histological Summary:* We have attempted to bring out the main structural points in each case, with, however, little or no attention to the total genetic picture presented by the case. This total genetic picture is reserved for Article III.

Further light upon the anatomical situation presented by each brain is offered in the description of the plates. The most inclusive view of each case from all available aspects: clinical, anatomical, histological, and genetic, together with points especially mentioned in the description of the plates, is given in Article III.

Synopsis of Findings of Case I.

a) Clinical.

1. Physical Examination.— P. Cap. was born June 19, 1897, and upon admission, at five years of age, was 32 inches tall and weighed 16 pounds. A photograph shows typical microcephaly, with a head roughly diamond-shaped when viewed from the side, with large ears; spinal caries of the dorsal region, with anterolateral curvature; thighs sharply flexed on abdomen, and legs flexed on thighs; arms slightly flexed and in position of contracture at elbows; strabismus. The eyes are described as "rather intelligent looking" despite the patient's inability to understand things said. Patient would turn head when spoken to, and follow persons or bright objects with his eyes. Spastic crural paraplegia; slight ability to move hands and arms, and ability to grasp small objects with the hands. Although unable to walk, the patient was able to push himself along the floor, and would come at command. Would stop crying when he heard food being brought in the customary way. Absence of control over bladder or rectum; daily vomiting. Patient is described as having had measles, and is said to have been able to kick up his legs at some time prior to his entrance to the school; but it is possible that this reaction, described by

the parents, was merely the effect of action of the muscles of the back and gluteal region. No history of epilepsy.

2. Family History.— Sister (born, Nov. 6, 1894) is an inmate of the Massachusetts School at the present time, having been admitted at the same time, at the age of 7. There are two other children, not microcephalic. The father and mother were born in Italy, and were about 33 and 23 years of age respectively at time of birth of patient. There are two other children, one of which was older than the patient's sister.

Parents are said to have been normal at time of the birth; birth was normal; and, although it was stated that the labor in the case of patient's microcephalic elder sister was a tedious labor with slow dilatation, the delivery was not instrumental in the case of either of the two microcephalic children.

3. Personal and Developmental History.— Patient seemed to the parents never to have developed mentally. He is described as having been fed but once a day, on bananas only.

4. History of School Progress.— Nil.

5. School Examinations.— Nil.

6 and 7. Practical Knowledge and Economic Efficiency.— Nil except for statements made under *Physical Examination* (see above).

8. Social History and Reactions.— Limited to interest in food on the instinctive level; would continue eating indefinitely if food was supplied. Patient wanted to be let alone.

9. Moral Reactions.— Occasional crying spells, possibly related to appetite.

10. Psychological Tests.— Quantitative tests not made. The microcephalic elder sister, obviously a little superior to her brother, measures 1.3 years of mental age by Binet scale. It is clear that the present case would have measured one year or less.

Waverley School History.— Patient's condition was unchanged throughout his stay. Patient was admitted April 12, 1902, when five years old, and died May 21, 1902.

b) Autopsy.

Notes not available; findings are limited to Gross anatomical examination: Microcephaly, dorso-spinal caries, with antero-lateral curvature; thighs sharply flexed on abdomen, legs flexed on thighs, arms slightly flexed and contractured at elbows.

c) Special Anatomical Description of Brain.

The measurements of the microcephalic brain, after preservation in formaldehyde for 11 years, were as follows: —

Length of left hemicerebrum LLH, 9 cm.
right LRH, 8.25 cm.
Greatest width W 8.75 cm.
Greatest height Heit 5 cm.
Cerebral index $\frac{W \times 100}{\text{Length}} = 97.22$ cm.
Greatest width left hemicerebrum WLH, 4 cm.
right WRH, 4.75 cm.
Arc frontal pole to Rolando left LArc FRo 3.08 cm.
right RArc FRo 3.07 cm.
Arc left Rolando to occipital pole LArc RoOc, 5.2 cm.
right RArc RoOc, 4.7 cm.

The brain gives the impression of being very simple and slightly developed. There seems to be a moderate degree of generalized thickening of the pia mater over the entire brain. The vessels are prominent but fail to show gross changes. It is noteworthy that the left hemisphere is longer than the right. The olfactory sulcus of the left orbital surface is short and possesses distal extremity deflected to the left. The olfactory sulcus of the right orbital surface is straight and extends almost to the anterior pole. The sulci on each orbital surface external to the olfactory sulci are small triradiate sulci whose extremities extend forward and sidewise well toward the margins of the orbital surfaces. Posteriorly these sulci approach the olfactory trigone.

The markings of the convexity are atypical and more markedly atypical on the right side. The frontal lobes consist of but two convolutions, the superior of which are broader than the inferior and marked by a number of short fissures. The inferior frontal convolutions are but slightly indented and fail to cover in the island of Reil. This deficiency of the frontal operculum is more marked on the left side than on the right.

The central area of the left convexity approaches normal in structure, although the frontal sulci run back to cover the precentral convolution. Upon the right side, the post-central gyrus is folded over the precentral gyrus, forming an atypical operculum therefor. The right postcentral gyrus is situated nearly a centimeter anterior to the left. Like the left central area, the left parietal lobe has an abnormal construction; this is divided atypically by the interparietal fissure; the postcentral and horizontal portions of the left interparietal fissure are connected with each other. The anterior third of the left interparietal fissure gives off a short descending branch, which branch separates the submarginal from the angular gyrus.

The occipital lobes upon both sides are exceedingly small and scarcely marked by fissures or depressions. On the left side, the demarcation of the occipital from the parietal lobe is effected by means of the transverse operculum. The general appearance of this area suggests the "Affenspalte"; on both sides the posterior extremity of the calcarine fissure is found to extend to the external surface of the hemisphere. Upon the left side this extremity terminates in a single cleft, pointing laterally. On the right side, the extremity of the calcarine fissure is a cleft running more frontalwards and finally terminating in a T-shape.

The comparatively large temporal lobes are almost entirely without sulcal markings, if we except the left second temporal gyrus, which is crossed by two transverse fissures in its middle and posterior portions. The pyriform lobule is well developed on both sides, especially on the right. Each pyriform lobule is marked off by a distinct *fissura rhinica* (Turner).

The lateral situation of the hippocampal lobes yields a notable degree of exposure of the crura cerebri and this appearance of an exposure of the crura is increased by the comparatively small number of transverse pontine fibers. Upon removal of the pia mater, the transverse pontine fibers are found arranged in bundles which are almost distinct from one another. The optic tracts seem comparatively very large and the olivary and pyramidal eminences upon the ventral surface of the medulla also stand out prominently. The cerebellum appears to be not remarkable on gross inspection.

d) and e) Microscopic Examination and Anatomical and Histological Summary.

Upon section the lateral ventricles show a moderate degree of dilatation. There is a slight subpial gliosis, involving both an increase of cells and an increase of neuroglia fibrils. Further points so far as important are placed in the general summary below.

Summary of Anatomical Examination.— The brain as a whole is very small. The cortex averages roughly 3 mm. in thickness. There are only two convolutional divisions in the frontal lobes. The right post-central gyrus forms an operculum which overlies the precentral nearly throughout its entire

length. The sulci of the precentral area are shallow; the individual gyri (especially on the left) are very narrow — some are not separated by sulci — and form thin fingers of white surrounded by grey cortex. The lateral ventricles are moderately large. In the postcentral (parietal) area, the sulci are deeper than precentral (frontal) but the medullary portion of the gyri is narrow. The descending ventricular horns are widened laterally. The structures at the base of the brain, though small, are not otherwise abnormal. The tapetum, optic radiations, and anteroposterior bundles are present. The striae of Lancisi (Indusium) are very noticeable in the anterior plane. The left is much larger than the right but decreases in size posteriorly until in the region of the Splenium, they are scarcely distinguishable.

The inferior olives stand out prominently from the periphery of the medulla; a distinct cleft exists on their antero-lateral surface, separating them from the surrounding portions, and the anterior arcuate fibers curve in deeply around the depth of this cleft.

The *cortex* is of average thickness (3 mm.). The cell supply is scant in all layers, but notably so in the medium sized and large pyramid layers, especially in the frontal and parietal areas. Many of the Betz cells are thin and fusiform. This seems particularly true of the left side.

The leaflets of the cerebellum are small, but do not lack in normal elements, nor present any anomaly.

The blood vessels are not remarkable.

Synopsis of Findings of Case II.

a) Clinical.

1. **Physical Examination.**— Born September 3, 1876; admitted to the school, April 1, 1893; died March 11, 1897. Characteristic microcephalic with receding forehead; knees stiff and flexed; feet extended; ankles rigid; thighs crossed; right knee crossed left; legs in contracture; hips can be slightly flexed; spastic paralysis of right arm; locomotion by rolling; patient could feed himself by use of left arm and hand; patient unable to walk or sit; head is described as asymmetrical. The right hemisphere of the brain is described at autopsy as having been one third larger than the left, and the skull flattening is described as having been especially marked in the left frontal region. No evidence of epilepsy.

2. **Family History.**— Born in Provincetown, of American parents; father 25 years of age, mother 22 years of age at birth of child. The microcephalic child was the first, seven other children following, none of whom is described as showing any deformity. The mother's health during pregnancy is described as having been good, and no extraordinary circumstances attended the delivery.

3. **Personal Developmental History.**— Physician (Dr. Newton) described the patient as having had a paralytic shock, at what time before the age at which first peculiarity was noticed (3 months) cannot now be stated. Another version of the cause is "infantile paralysis," but whether this diagnosis, made in 1876, has reference to epidemic poliomyelitis cannot now be stated. The patient is described as having passed through measles, whooping cough, and chicken pox.

4 and 5. **School Progress and Examinations.**— Nil.

6. **Practical Knowledge.**— Able to feed himself with left arm and hand.

7. **Economic Efficiency.**— Nil.

8. **Social History and Reactions.**— Patient appears to understand certain things said to him. Unable to talk. (Is described by family as able to say "Mamma.") Patient could make cackling sounds of a loud and shrill nature. By means of these sounds and by gesticulating with the left hand, patient was able to express clearly: pain, pleasure, displeasure, hunger, and thirst; and was apparently able to make the other boys in the ward able to understand these expressions. Patient took interest in events about him, watching the boys at play, liking to look at pictures and bright colors. Patient's hearing was good. He enjoyed music and was able to hum several tunes correctly.

9. Moral Reactions.— Patient is described as gluttonous, swallowing food without chewing. He is described by the family as passionate.

10. Psychological Tests.— No quantitative tests made. Patient would probably measure less than a year.

Waverley School History.— Is sufficiently described above. Death was due to septicaemia following gangrene of extremities.

b) Autopsy.

The description of the autopsy is taken from the report of Dr. Taylor:

The autopsy was made about twenty-four hours after death, the head only being examined. The body was undersized and markedly deformed. The head was markedly microcephalic in type, the circumference $17\frac{1}{2}$ inches; from root of the nose to the occipital protuberance measured 11 inches. The skull was thick, particularly over the parietal regions. Corresponding to two marked depressions in the frontal portion of the brain and easily seen before the removal of the dura were two bony prominences on the inner table of the skull. Dura and pia normal. The brain completely filled the cranial cavity, which was asymmetrical. The left hemisphere was markedly smaller than the right, with abnormal convolutions in both. Very striking at the autopsy was the posterior portion of the brain, including the upper parietal and occipital lobes. The cortex here was so greatly reduced in thickness that fluctuation from the distended ventricle was easily obtained on the left side. The right hemisphere appeared approximately thirty-three and one third percent. larger than the left.

The brain was hardened in formalin, and after hardening weighed 620 grams.

Further examination of the brain 16 years after removal yielded the following measurements: —

Length of left hemicerebrum, LLH, 14.5 cm.
right LRH, 14.5 cm.
Greatest width W 11 cm.
Cerebral index, $\frac{W \times 100}{\text{Length}} = 76$ cm.
Greatest height Heit 5.75 cm.
Greatest width left hemicerebrum WLH, 5. cm.
right WRH, 6. cm.
Arc frontal pole to Rolando LArc FRo 8. Left.
right RArc FRo 9.5 cm.
Arc left Rolando to occipital pole, LArc RoOc, 6.5 cm.
right RArc RoOc, 5. cm.
Frontal pole to corpus callosum, FCorp Cal. 3.2 cm.
Right optic commissure 6 cm.

There is considerable asymmetry in this brain. The hemispheres do not differ materially in length, but the right is considerably broader than the left. This is particularly noticeable at the frontal pole. On the orbital surface the left gyrus rectus is narrower than its opposite, and the convolution which forms the margin is shrunken and shortened. This shortens the distance from the frontal tip to the fronto-temporal angle, and deflects the longitudinal fissure toward the left.

There is a circumscribed area of microgyria about midway the second frontal gyrus on either side, that on the left is more extensive. The third left frontal is complex and the convolutions are well rounded.

The central region marks the beginning of an extremely atypical cortex. The precentral gyrus on both sides is of fair width, and well rounded. The postcentral on both sides is much shrunken and narrowed in its upper half. The fissure of Rolando very nearly cuts the margin of the superior longitudinal fissure on the left, while on the right, its upper extremity is one centimeter from the margin.

The entire parietal cortex over the vertex is much shrunken, the convolutions are very narrow and flat, and on the left a small focus has sunken below the surrounding surface. The normal markings are not made out, on account of the alterations in the cortex. At the parieto-temporal juncture, the convolutions assume a more nearly normal outline. This does not include the upper part of both the supramarginal and angular gyri on both sides, both of which are severely affected; more particularly the former and the cortical change is more extensive and extreme on the left than the right.

The temporal lobes are asymmetrical temporo-frontal distance L. 4. cm. Rt. 4.5 cm.

Both first temporals are very narrow; the right particularly so. The second temporals are broad with transverse markings. The left hippocampal gyrus is completely hidden by the folding over of the third temporal, and only the extreme anterior portion of the pyriform lobule is seen. On the right, the hippocampus and pyriform lobule are not remarkable.

The occipital lobes are very small and show the same changes on the superior surface as the parietal upper regions; the lateral surfaces are more nearly normal. The posterior extremity of the calcarine fissure extends well on to the outer surface of the occipital tip. On the left, the distortion of the parietal cortex has brought the calcarine fissure for a considerable distance nearly to the upper margin of the hemisphere.

The pons, medulla, and cerebellum are not notable on gross examination.

d) Microscopic Examination.

Nerve fibers have been replaced in many instances by patches of rather dense neuroglia tissue. In the prefrontal sections this condition is marked, especially on the right side; farther back the areas of gliosis show cavitation with numerous glia cells in rather thin encapsulating walls, and a number of large pigment-bearing phagocytes. The major amount of cell loss is in this portion of the frontal region confined to the mesial surface. Farther back the frontal cortex shows thinning of all its layers, except the external layer of small pyramids. More posteriorly the total brain sections demonstrate a special loss in size of the two second frontal convolutions; but this loss is more marked on the left than upon the right side. The mesial gyri in this region are also characterized by extreme fiber loss, and the cells which persist are arranged patchily. The sections here indicate that there are more nerve cells than the number of persistent nerve fibers would lead one to expect. More posterior sections exhibit the same higher degree of degeneration upon the left side and this degeneration is shared by both the second and the first frontal gyri. Sections through the plane of the anterior extremity of the lateral ventricles show a marked dilatation upon the left side, with a complete degeneration of the fibers surrounding the ventricle superiorly, externally and upon the external half of the inferior border, whereas the fibers on the mesial border and upon the internal half of the inferior border of the ventricle are preserved. The fiber communications of the first and second frontal gyri that underlie portions of the brain are represented by only a narrow band of fibers.

When the sections begin to cut the corpus callosum, it is found that this body is made up of a very thin bundle with a small number of stained fibers. The white bundle and the third left frontal gyrus are thinned out and in this region there are many large pigmented phagocytes. The first and second frontal gyri in this plane are almost completely degenerated as is also the tissue of the superior mesial surface. The knee of the corpus callosum is also very thin. The lower portions of the hemisphere appear more nearly normal than the upper portions, although the gyri in the lower portions of the hemispheres are too narrow and long as compared with normal. Some sections exhibit a multiple cavitation in the degenerated areas with the cavities surrounded by a dense gliosis. In a plane still farther back behind the temporal lobes, a considerable degree of satellitosis is found in both superior frontal gyri. The lateral ventricles are markedly dilated, although the left more so than the right. Small areas of

Betz cells are found in the precentral gyri on each side, although the tissue for the most part above the temporal lobes is markedly degenerated. In view of this marked degeneration, the internal capsule does not appear to be so shrunken a structure as one might expect. The superior temporal gyrus is itself moderately involved in the degeneration, more particularly on the left side. The transverse temporal gyri are markedly shrunken. Planes posterior to the above continue to show extreme degeneration of tissues superior to the Sylvian fissure and even including the mesial surface on the left side. Of these gyri the callosal gyri are the least affected. The superior temporal gyri and insulae of both sides show equal degrees of degeneration. On the right side, the inferior parietal lobule shows a certain degree of change, but the alteration of the superior parietal lobule is extreme, if we except the tissue along the longitudinal fissure and upon the mesial surface. Large amyloid granulations are found at the base of the pineal body.

The thinning of the cortex in sections posterior to the above is extreme except in the temporal lobes. Appearances suggest that the right superior colliculus is smaller than the left. The pyramidal bundles are smaller on the left side than on the right, their magnitude being reduced possibly one third. The tapetum and optic radiations are markedly thinned out on both sides, although more extremely on the left. A section from the extreme tips of the right lobe exhibits a curious appearance of cells in islands separated by fibers.

e) Anatomical and Histological Summary.

The interest of this case naturally lodges in the combination of microcephaly, hydrocephalus and posterior-lying focal lesion of the cerebral cortex. It is supposed that this latter lesion may have been due to an old cortical lesion, possibly of the nature of cerebral lesions sometimes occurring in infantile paralysis. The brain is somewhat asymmetrical; in particular the right hemisphere is considerably broader than the left. It is an interesting inquiry what relation may be held between the focal parietal, occipital lesion and the shrunken left frontal region with its circumscribed area of microgyria in the second frontal gyrus.

When we find that the nerve fiber loss has been replaced by patches of rather dense neuroglia tissue, we are bound to inquire whether this latter condition of gliosis is to be regarded as an acquired reaction following the destruction of tissue which had been properly laid down, or whether this gliosis is to be regarded as gliosis relative to fundamental absence of nerve fibers. The patchy nature of the gliosis rather inclines the examiner to the belief that we are dealing with a lesion in some sense acquired. The fact that large pigment-bearing phagocytes are found in the gliotic walls of the cavities found in some areas of gliosis is perhaps not decisive; but phagocytosis is consistent with the hypothesis of acquired lesion.

Again the irregular preservation of nerve fibers about the ventricle (mesial and internal fibers of the inferior border preserved) rather suggests acquired lesion.

What the significance of the multiple cavitation in degenerated areas surrounded by dense gliosis may be is doubtful. We may think of the resemblance of these areas to cavitation in the spinal cord in syringomyelia. Patchy nerve cell and fiber loss, cavitation in areas of gliosis, the occurrence of pigment-bearing phagocytes, to say nothing of the somewhat suggestive history of early brain lesion, may well lead us to regard this case as one of secondary amentia in the sense of Tredgold. Whether we may add to this list of factors the presence of satellitosis in certain areas is questionable. On the whole, however, in the present stage of our knowledge concerning satellitosis, it would appear that the finding is rather indicative of an active or acquired lesion. (One here bears in mind the satellitosis about nerve cells in poliomyelitis and other conditions, which may be repeated experimentally; but one also has to bear in mind the satellitosis in certain cases of atrophy of the brain in the senile period where the satellite cells may be regarded possibly as reactive to the condition of atrophy.) It might be that hypoplastic

nerve cells could be affected by satellitosis in ways identical with those of the condition just mentioned. The presence of large amyloid granulations at the base of the pineal body may have significance in these directions but we must at present omit consideration thereof.

The greater degree of disease on the left side of the brain is supported by the smaller size of the pyramidal bundles on the left side above the decussation.

In our judgment the case then is pretty clearly one of secondary amentia.

Synopsis of Findings in Case III.

a) Clinical.

Little is known as to Case III although the patient, D. C., born in 1863, was a somewhat well-known figure in Boston and vicinity all his life, which was passed for the most part outside of institutions. When outside of institutions, patient was regarded as a harmless microcephalic, alternately the pet and the butt of the community. He was of a vagrant tendency, unable to support himself but able to curry favor with various kindhearted persons, who would keep him in their houses for a few days or weeks until the vagrant spirit set in once more. He was known as "Peanut head" by the children, and became later known as "Zip," being a namesake of a subject exhibited at circuses and variety shows. In fact, the patient is said to have been exhibited for a time in a nickel theatre in Boston under the name of "Zip, the wild man of the Philippines." The patient entered the hoax with intelligence, wore a buffalo robe, had his hair cut in a peak behind, and rattled a tin cup, saying "*Education! Education!*"

The patient, born of Irish-American parents (father alcoholic), is said to have been a seven-months child, born in a fracas between his father and a policeman. The patient's father is said to have been occupied with beating the mother when the policeman interposed. The policeman's club is said to have glanced off onto the head of the mother, who died within twelve hours of giving birth to the patient.

The patient is said to have learned to walk and talk at the usual time, was unable to get through the primary school, but is said to have picked up reading and writing. He was at first in a Catholic home; later in a home for destitute children; still later in the State Infirmary in Tewksbury, where he was operated upon for rupture; and he was at the Bridgewater State Farm in 1903. The patient had no abnormal sexual tendencies. He was easily susceptible to alcohol. It is said that at the age of 30 he had a fit, probably epileptic in nature.

The history of the patient just before his death makes a somewhat moving story. Upon good authority, it is related that he was in perfect health until September 15, 1908, being six days before he died. Upon September 15, the patient endeavored to steal a quarter from a kind hostess who had kept him in her house for a number of days, as she had done at previous times. He was found out in his design and was upbraided roundly by his hostess for being a liar. The patient became furious, went to his room in his hostess' house, began to mutter to himself and to tear his hair, and then refused to eat or drink. He is said not to have eaten anything until his death. He was admitted to the Danvers State Hospital *in extremis*, September 20, 1908, and died a few hours later.

b) Autopsy.

Head and trunk were examined by E. E. Southard and the cord by M. M. Canavan.

White male, age 45, 126 cm. long; weight, 88 lbs. Trunk symmetrical; thorax narrow; costal angle acute. Shoulders and hips of equal width. Spinal column straight. Extremities symmetrical and of appropriate length with respect to trunk. Head microcephalic. Skull symmetrical.

Measurements:		
	Glabello-occipital length,	14.5
	Basi-bregmatic height,	12.
	Vertical index,	81.
	Minimum frontal diameter,	9.5
	Greatest parietosquamous breadth,	11.5
	Cephalic index,	79.
	Horizontal circumference,	43.

The glabella is prominent. The general outlines are shown in the accompanying sketch. Extremities rigid. Slight greenish discoloration of abdomen. Pupils: left 5 mm., right 4 mm.

Peritoneal cavity.— Serosa and contents normal. *Appendix* infracecal, free, 7 cm. long. *Mesenteric lymph nodes* not enlarged. Omentum thinly clad with fat.

Pleural cavities.— Slightly moister than normal. Adhesions absent. Roughening of pleura at both apices, in areas less than 3 cm. broad.

Pericardial Cavity.— Not remarkable.

Mediastinum.— No sign of thymus.

Heart.— Weight, 210 grams.

Measurements: T. V. 11. cm. P. V. 5 cm. L. V. 1.5 cm.
M. V. 9. cm. A. V. 6 cm. R. V. 0.4 cm.

Muscle normal. Endocardium shows a slight thickening adjacent to aortic valve. Valves normal. Cavities contain cruor clot. Coronary arteries normal.

Lungs.— Left 355 gr.; right 535 gr. Both edematous and congested behind and below. The dependent portions of both lungs, especially right, are coarsely mottled and non-retractile, and contain bronchial plugs of semifluid pus. There is no palpable deposit of fibrin on the pleurae. The larger *bronchi* are free from pus. The *vessels* are normal. *Bronchial lymph nodes* not remarkable.

Spleen.— Wt. 105 gr. Fir; dark red, without thickening of trabeculae or enlargement of malpighian bodies. Splenculus near hilus below.

Gastro intestinal tract.— Stomach: Contains little or no fluid. Walls covered with brownish mucus which is tenacious. Duodenum negative, also jejunum. In various parts of the ileum greenish black semi-solid pasty material seen. Walls covered with mucoid exudate. No ulceration or hemorrhage seen. The colon also for some distance after passing ileocecal valve shows black content, but at the sigmoid the content is only cheesy mucoid material. Rectum negative.

Liver: Wt. 990 gr. Border sharp. Substance of normal consistence and nut-brown in color. *Gall bladder* not remarkable.

Pancreas.— Small.

Adrenals.— Show no lesion.

Kidneys.— *Left* weighs 170 gr. Measures 13 × 5 cm., is very red and drips blood on section. The capsule strips with fair ease leaving a smooth surface. The cortex is 1 cm. thick, the pyramids are a large distance from pelvis to capsular surface, being 2.5 cm. The pyramids are uniformly diffusely red, while the cortex, mahogany in color, is markedly injected. Kidney substance bulges on section. Two ureters of usual size connect the kidney with the bladder. The *right* kidney measures 9 × 2.5 cm.

Two yellow-white pouches 2.5 × 3 cm. in diameter, spring from either pole of the kidney and descend to bladder as independent tubes 1.4 cm.–1 cm. in diameter. They are 14–18 cm. in length and above the fundus of the bladder appear to unite and descend on right side of bladder. The bladder is deeply congested and in the upper and right side numerous cysts, closely set, appear in wall. Dissection of the ureters shows fine openings into the bladder, two on the left side corresponding with the two ureters and situated appropriately with relation to the trigonum, two on the right side symmetrically placed with respect to those of the left side but draining only the external of the two right ureters. The internal of the right ureters opens into the bladder by a relatively large orifice situated on the lateral surface near the summit.

Organs of neck.— Thyroid weighs 15 gr. Normal on section. Under and along upper border of common carotids a glandular bit of tissue held together by adipose and areolar tissue seen. It is yellow in color and contains numerous glistening red bodies.

Aorta.— Smooth and elastic throughout.

Genito urinary.— Testes yellow-white, small, edematous, do not thread well.

Head.— *Hair* stiff, black, closely cropped. *Scalp* thick and may be readily gathered into loose folds. Calvarium moderately dense. *Dura mater* not adherent to calvarium. *Sinuses* not remarkable. *Middle ears normal. Pituitary body normal.* Brain wt. 610 gr. Placed in formalin for later description. Brain reweighed after formalin containing 8% NaCl, 615 grams.

Measurements: Cerebrum, antero-posterior,	12.5	cm.
" dorso-ventrally,	9.	cm.
" laterally,	10.75	cm.
Cerebellum, antero-posterior left,	4.5	cm.
" " " right,	4.5	cm.
" greatest dorso-ventrally,	3.5	cm.
" laterally,	8.5	cm.

Width of pons between origins of 5th nerves, 3 cm.

Antero-posterior basal measurement of pons, 2.5 cm.

Pia mater, everywhere clear. Vessels show moderate injection; small pacchionian granulations alongside longitudinal fissure from middle of superior frontal gyri as far back as superior parietal lobules. Sylvian and Rolandic fissures well marked, almost symmetrical. Gyri of fairly even width. Gyri and sulci so disposed as to yield the impression of a normal though small brain. No sign of Affenspalte. Upon superficial examination, besides Rolandic and Sylvian fissures are made out (before stripping pia), ascending ramus of Sylvian, second and third frontal sulci, first frontal sulcus (interrupted), intraparietal sulcus with branches, first and second temporal sulci, parieto-occipital, calcarine, collateral and calloso-marginal sulci. Orbital surfaces normal. Slightly asymmetrical markings. Cerebellae laminae not remarkable possibly in places wider than usual, notably in Amygdala. The inferior vermis is either absent or obscured by close proximity of inner surfaces of the amygdalae.

Anatomical Diagnosis.

Unequal pupils.
Chronic pleuritis.
Slight chronic endocarditis.
Pulmonary congestion.
Purulent bronchitis.
Acute nephritis.
Cystitis, acute.
Cystic formation in bladder wall.
Abnormality of ureters.

Scalp thick.
Calvarium dense.
Microcephalic brain.
Brain weight, 610 grams.

c) Special Description of Brain.

Subsequent to examination on the autopsy table, the following notes were made concerning the brain:

Length left hemicerebrum, LLH, 16.9 cm.
right LRH, 16.2 cm.
Width W 12, 10.1.
Cerebral index 10.1 × 100, over 16.9 cm.
Greatest height Heit, 7 cm.
Arc frontal pole to Rolando, LArc FRo, 9.3 cm.
right, RArc FRo, 9.4 cm.
Arc left Rolando to occipital pole, LArc RoOc, 8.4 cm.
right, RArc RoOc, 8.2 cm.
Angle of Rolando with long, fissure Right = 53°
" " " " " " Left = 53°
Temporal tip — frontal pole = 3.1 cm.
" " occipital pole = 10.3 cm.
Cerebellum.— Bilateral diam. = 8.7 cm.
Ant. post. at brachial exit = 5.2 cm.

Flocculus fairly developed. Lobes uniform in size and outline.

Fifth nerve leaves the bulb somewhat higher on the right than on left. Cranial nerves otherwise not remarkable.

Basilar vessels show no alterations except slight diffuse thickening of the vertebrals, especially seen on the right about 2 cm. below the basilar.

Frontal segment mesial from corpus callosum = 2.5 cm.
Occipital segment, splenium — occipital pole = 5.7 cm.

Right Hemisphere.— The right Sylvian fissure (6.4 cm.) is very simple, its borders closely approximated. The insula is visible only at the base of the ascending ramus; there is no anterior branch.

Central Rolandic Fissure.— The Fissure of Rolando is 7.6 cm. in length, has no branches and does not cut through the margin of the hemisphere. The genua are represented by two flat curves in the course of the fissure. The superior genu is 1.7 cm. from upper extremity; the inferior, 5.3 cm.

Occipito-parietal.— Rises where the internal border of the cortex cerebri is in apposition with the ant. corp. quad. It approaches the occipital pole in a comparatively horizontal direction. At the margin it bifurcates, forming a broad Y. The occipito-calcarine stem is short, 1.2 cm. The *calcarine fissure* forms an acute angle with the parieto-occipital and continues posteriorly in an S outline extending downward and backward, then outward and upward.

The *precentral fissure-complex.* In the frontal cortex, including and lying in front of the fissure of Rolando, there is one principal fissure, triradiate in form corresponding apparently to the precentral sulcus, frontal from which extends the inferior frontal sulcus. Above the dorsal extremity of the vertical ramus and separated from it by a narrow, plump gyrus, is a short, deep fissure 2.3 cm. in length which cuts the superior margin at right angles. (Sulcus cruciatus?). This sulcal arrangement divides the frontal cortex into two gyri, both of which anastomose with the precentral and anteriorly with each other. The superior frontal convolution is broad and long, and is marked by four short fissurettes which generally

follow an oblique line. The inferior frontal is short and broad, and is marked by three shallow fissurettes, and a deep ascending Sylvian fissure. Very far frontal is a T-shaped sulcus, whose stem runs from a point very near the fronto-Sylvian angle and 0.6 cm. from the orbito-frontal margin to a point 0.8 cm. from the superior margin where it opens into a longitudinal sulcus 2.1 cm. in length, slightly concave mesad.

Temporal and Occipital Fissures.— The parietal lobe presents an anomalous fissure-complex — the postcentral sulcus (1) cuts the margin of the superior longitudinal fissure and extends upon the mesial surface for a short distance. The horizontal interparietal is represented by a very short ramus (2) (1.5 cm.) which springs from the postcentral at the junction of the middle and lower thirds, mesad to this horizontal ramus and 1.4 cm. from the meso-dorsal margin is a deep, curved, horizontal fissure, slightly curved with the convexity mesad. This fissure does not descend vertically into the cortex, but obliquely outward, thus forming a thin operculum which overlies the tips of the horizontal convolutions which form the superior parietal lobule. At its occipital extremity this sulcus opens into a horizontal one 4.3 cm. in length which lies 1.5 on the meso-occipital surface and ends laterad in a forked extremity. The lower lip of this fissure is opercular in character and suggests an *Affenspalte.* The corresponding sulcus on the left side is quite simple, not at all resembling the one just described.

The superior parietal lobule is narrow and its gyri vary in width from 1.2 cm. to 0.4 cm. The supramarginal gyrus is fairly broad — 0.9 cm. in width — but the convolution is short. It anastomoses anteriorly with the postcentral and posteriorly by means of a bridging arm, with the angular gyrus. The latter is made up of three parts which extend horizontally and assume a fan-shaped outline. The gyri are comparatively broad and almost free from ramifications. This gyrus encroaches upon the occipital lobe which is very small. The tips of the occipital lobes of both sides point away from the median line thus exposing a portion of the cortex which is ordinarily found on the approximated mesial surface.

The Temporal Lobe.— The temporal lobe is divided by two very simple fissures. The gyri are relatively broad, smooth and well-rounded, with short shallow fissures at their bases. The sulci on the basal surface are very simple. A deep fissura rhinica separates the uncus definitely from the tip of the temporal lobe. The *inferior temporal sulcus:* It is deep with sloping walls, and is interrupted about midway by an arm from the fusiform gyrus which anastomoses with the third temporal convolution.

The Left hemicerebrum.— The configurations of the area anterior to the Rolandic fissure on the left hemisphere are almost identical with those on the right, in every detail.

The temporal lobe also is uniform with the right.

The parietal lobe.— The ascending ramus of the interparietal sulcus is separated from the horizontal and descending portions by an anastomosing arm between the postcentral and superior parietal gyri. The posterior extremity of the horizontal limb enters into a roughly star-shaped formation. The posterior portion of the second temporal gyrus, representing the area of the angular gyrus, is a separate fragment; below this a continuation of the second temporal fissure extends backward to within 3.2 cm. of the longitudinal margin.

The occipital lobe is noticeably larger than that on the right. Its markings are somewhat complex and may be best studied on the figures and photographs.

The configuration of the basal surface is uniform with the opposite side.

The meninges are not particularly remarkable. The pia is slightly thickened and the vessels injected.

There is noticeable occipital asymmetry; the right side is shorter than the left, and points away from the median line.

The orbital surfaces incline upward to a marked degree both postero-anteriorly and meso-laterally, thus partly exposing them to lateral view. The sulcus pattern here is a very simple tri-radiate one, very similar on both sides. The olfactory bulbs are 3.5 cm. in length, and not notable in development.

Rt. precentral are 9.5 cm.
" postcentral " 8. "
L. precentral " 10. "
" postcentral " 8. "

The markings on the hemispheres are very nearly symmetrical. There is lack of development of both frontal and parietal cortex; possibly involving the former to a greater degree.

The frontal lobes are very pointed at the extreme pole and are made up of only two convolutions. The superior is somewhat narrower than the inferior and is marked with short, oblique fissures, and triangular depressions. The Island of Reil is exposed on both sides: somewhat more on the left than right. At the base of the frontal gyri, and separating them from the precentral convolutions on either side are short, deep, transverse sulci, which resemble the sulcus cruciatus of the dog's brain. In fact this specimen in general contour bears a rather noticeable similarity to the brain of a dog. The convolutional pattern of the central region is very simple. The pre- and post-central gyri on the right are curved only at the genua. The Rolandic fissure on this side points occipitalward at its upper extremity, and nearly cuts the margin of the hemisphere. On the left side the precentral gyrus is interrupted at the point corresponding to the inferior genu; the upper knee is lacking. The Rolandic fissure on this side is formed at its upper extremity by a formation with a convolution of good width between it and the margin of the hemisphere.

The horizontal portion of the right interparietal sulcus is separated from the postcentral portion by an annectant gyrus, between the superior and inferior parietal lobules. It curves around the supramarginal and angular gyri, and seems to form an offset to a portion of the superior parietal lobule. The latter is narrow and marked with transverse fissures. On the left side, the inferior postcentral (descending interparietal) fissure is continuous with the horizontal interparietal.

The superior post central is separated from the former by an annectant gyrus connecting the post central with the superior convolution. A similar opercular formation exists on the left as on the right, but it is made more complex by a reduplication caused by the presence of an additional sulcus which extends with a single interruption, in a curved outline from the posterior extremity of the parieto-occipital fissure to the base of the second temporal from the angular gyrus.

The occipital lobes are very small, and are marked by a few short fissures. The calcarine fissure extends upon the outer surface, ending in a single upward curve on the right, and in a T formation on the left.

The temporal lobes are remarkable only for their simplicity. The gyri are nearly straight, and almost entirely without markings. The first and second convolutions are of good width and well rounded. The third is somewhat narrower and flattened.

The pyriform lobules are well developed, the right apparently more so than the left and are limited anteriorly by a well marked fissura rhinica (Turner) (?).

The markings on the base of the brain are as singularly symmetrical as they are on the upper and lateral surfaces.

The mesial surfaces are not described because the hemispheres were not separated.

d) Microscopic Examination.

The total brain sections stained by the Weigert myelin sheath method permit the observation of a marked gliosis in the white matter in the frontal region, especially about the vessels. In places the cellular gliosis is general and marked and in particular there is an abundance of spider cells in the subpial region. Satellitosis is found in addition to the above mentioned cellular gliosis and in certain areas farther back in the frontal region (sections № 146–151) there appears to be a particular degree of satellitosis about the cells in the lenticular nucleus. Also in this posterior portion of the frontal region, the gyri

begin to show a more marked thinning of their cell layers than is found farther forward. The mesial surface of the uncus of both sides and the basal tissues lying between show a marked subpial gliosis. Large cells were demonstrated in the appropriate region about the ventricle and there was a marked sub-ependymal gliosis with pigmented glia cells and certain large round cells. These findings were especially noted from the mesial angle of the thalamus.

Practically no areas fail to show general cellular gliosis but thinning of the cell layers is shown in addition to that mentioned above for the frontal areas (sections # 156–186) also in the parietal areas (sections # 331-356). The tapetum, optic radiations and longitudinal bundles are intact. The tissue permitted the employment of Van Gieson's stain which demonstrated the subpial gliosis especially well, as also a perivascular gliosis in many places, with lymph spaces apparently containing glia cells (no exudate is present in any area studied). The stem of the olfactory bulb is found infiltrated with amyloid bodies. There was a slight focal thickening of the intima in the basilar artery.

The blood vessels of the white matter appear numerous and there is a good deal of perivascular gliosis. No abnormality of vessel walls is anywhere shown.

e) Anatomical and Histological Summary.

The gyri are everywhere narrow — about 0.8 cm. at their summits — and simple in arrangement. The primary and secondary sulci are of ordinary depth, not complicated by collaterals, and their walls, as a rule, are not approximated at the summits, though the sulcal floor is not exposed.

The frontal lobes are small, and pointed at the anterior poles; the orbital lobes lie in a more or less vertical plane. The markings are notably uniform on both sides.

The temporal lobes are comparatively large and are very simply convoluted.

The parietal lobes present a greater diversity of sulcation than any other part of the brain. The pattern of the two sides varies considerably. This is described in detail in another place.

The occipital lobes are quite at variance in size, the right being considerably shorter than the left. A deep transverse sulcus about midway between the parieto-occipital fissure and the tip of the occipital lobe forms a relatively large operculum and seems to account for the occipital shortening. This lack of uniformity in the size of the occipital lobes is plainly seen on the basal surface. (See illustration).

The brain was not divided longitudinally between the hemispheres and consequently a detailed examination of the mesial surfaces was not made.

Angle of Rolando with long fissure, right = 53°
" " " " " " left = 53°

Temporal tip — frontal pole = 3.1 cm.
" " occipital " = 10.3 cm.

There are varying degrees of satellitosis nowhere marked in the cortex, but rather more extreme in degree in the basal gray matter.

The cortex averages about 3 cm. in thickness.

The cortical cell-supply seems somewhat reduced in amount, especially in the frontal and parietal lobes. Betz cells prominent. The lack seems to be mainly in the outer layers of medium sized and large pyramids — possibly at times the inner layer of large pyramids.

There is considerable subpial gliosis throughout. This is particularly true on the base of the brain between the crura cerebri and the base of the olfactory trigone, especially in the tempero-frontal angle, where the glia network is infiltrated with amyloid granules.

There is also considerable subependymal gliosis — both cellular and fibrillar with pigment in the glia cells. This is confined mainly to the opposed surfaces of the optic thalamus.

Synopsis of Findings in Case IV.

a) Clinical.

Case IV, like Case III, is a Danvers State Hospital case. The patient, M. S., stated to be 62 years of age at death, September 27, 1911, was under hospital observation only from July 26th to her death. The patient was an old almshouse case (Salem and Beverly).

Physically on admission the patient was 4′ 8¼″ tall, and weighed 111 pounds, with arteriosclerosis, slightly enlarged liver, teeth absent, albuminuria, impairment of vision and hearing, thick speech, and a tic of the right side involving head and shoulder.

The meagre history of the patient indicates that she was of old American stock. She had been regarded for the twenty-eight years during which she had been under almshouse observation, as feeble-minded. She was not selfsupporting although she would work, receiving a dollar or a dollar and a half, for a week or more, ranging up to two or three months. At the end of her employment, she would leave with her clothes tied up in a bundle covered by a cloth. Whenever the patient appeared upon the street, she attracted much attention and had a crowd of small boys following her. The tic observed at the hospital was apparently of long-standing and it is said that the twitching was more noticeable when the patient was pleased.

Shortly before admission to Danvers the patient had become untidy. After admission, the patient complained of headaches, was at times restless, was markedly amnesic; did not know the date or her whereabouts, and her attention was hard to obtain. Patient apparently reacted to auditory and visual hallucinations. She said she had seen little women sit on her knees and that they had blue eyes and red hair.

b) Autopsy.

Body of a well developed, well nourished, white female 141 cm. in length. Rigor mortis present everywhere. Skin smooth, hair brown, rather thin. Pupils, right 6 mm., left 5 mm. No teeth on either jaw. No glandular enlargements. No decubitus. Tibial crests smooth. Face asymmetrical.

Ventral Section.— Panniculus over thorax .8 cm., over abdomen near umbilicus 2 cm. Muscle good color. Omentum extends to umbilicus, moderately filled with fat. Lower border of liver extends 8 cm. below ensiform, lower border of stomach extends 6 cm. below ensiform. Few adhesions between omentum and right parietal peritoneum. Adhesions about spleen. Appendix retrocedent, lies over brim of pelvis 5 cm. in length, mesentery throughout. Peritoneal mesentery lymph nodes slightly enlarged, no fluid in abdominal or pelvic cavities. Uterus in right side of pelvis. Diaphragm arches to 4th interspace left, to 4th interspace right. Sternal bone marrow well colored. Internal mammary arteries are not sclerosed.

Thorax.— Left lung adherent along entire posterior region. Adhesions in right lung lie between middle and lower lobes and pericardium, and between the upper, middle and lower lobes. Apex free. No fluid in the pleuric cavity. Anterior edges separated by 2.5 cm. Precordia exposed. Pericardium contains 2.5 cc. of clear straw colored fluid.

Heart.— Greatest width 10 cm., greatest thickness 8 cm. Epicardium contains a small amount of fat. Over the right ventricle is a milk patch slightly irregular in outline, approximately 2 cm. in diameter. Superficial vessels slightly tortuous. Heart contains fluid blood. Weight 225 grams.

Measurements: T.V. 12 cm. P.V. 7 cm. M.V. 8.5 cm.
A.V. 7 cm. L.V. 1.3 cm. R.V. .5 cm.

Endocardium grey, thickened, aortic valve shows slight thickening at line of attachment of cusps,

mitral valve thickened along border. Tricuspid slightly thickened, pulmonary lies flat against wall and shows no thickening. Interauriculus septum not intact. Foramen ovale is patent but is functionally closed. Coronaries are free from sclerosis. Arch of the aorta smooth.

Lungs.— Left lung weight 345, adhesions between upper and lower lobes. Upper lobe air containing throughout, a small fibrous scar at the apex. On section posterior portion darker but crepitant. Lower lobe deep red mottled in lower portion, floats in water. Bronchi in lower lobe congested, upper lobe nothing of note.

Right lung weight 325, adhesions between upper and middle lobes, air containing throughout. Small scar on anterior surface near apex. Upper lobe pale, lower lobe slightly congested; lungs float in water. Bronchi slightly congested. Bronchial lymph nodes not enlarged.

Abdomen: Spleen.— Weight 50 grams. Measures $9.5 \times 5 \times 1.5$ cm. Capsule grey, slightly wrinkled. On section soft, mottled. Trabeculae and Malpighian bodies distinct.

Gastro-intestinal Tract: Stomach.— Lesser curvature 20 cm., greater curvature 26 cm. Stomach filled with about 100 cc. of thick yellow mucus. Mucous membrane slightly congested, rugae distinct, no hemorrhages of ulcers.

Intestines filled with a pale yellow fluid, fecal matter and mucus. Intestines thin walled throughout. Slight congestion of duodenum and jejunum. Peyer's patches not enlarged, no hemorrhages or ulceration. Mucus membrane of colon slightly congested, no hemorrhages or ulcers.

Liver.— 975 grams, 20×20 in quadrate lobe $\times$ 13 in left lobe, 5 cm. in thickest portion. Border well rounded, on anterior surface of quadrate lobe near upper border are three furrows 3.5 cm. in length. On section brownish, lobulation distinct not friable.

Gall Bladder.— Filled with dark, green brown bile.

Pancreas.— 13 cm. long by 2.5 cm. in width.

Adrenals.— Right adrenal weighs 4.8 grams, left adrenal weighs 5 grams. On section firm.

Kidneys.— Right kidney weighs 110 grams, measures $10.5 \times 5 \times 3$ cm. Capsule strips readily, cortex pale, .7 cm. Vessels slightly injected. Pyramids slightly more congested than cortex. On section substance bulges slightly beyond capsule. Left kidney weighs 135 grams, measures $11 \times 5.5 \times 3.5$ cm. Pale, otherwise like the right.

Bladder.— Not unusual. Retroperitoneal lymph glands slightly enlarged and darker than usual.

Neck Organs: Oesophagus.— Nothing of note.

Thyroid.— Fairly symmetrical. Weight 12 grams. Left lobe a little more compact than right lobe.

Larynx, Tongue, and Tonsils.— Nothing of note.

Pelvic Organs.— External os of uterus was closed, canal filled with mucilaginous secretion. Uterus atrophied, shortening of right broad ligament and is adherent to ovary on this side.

Ovary is atrophied, left tube apparently normal.

Rectum, nothing of note.

Head.— Calvarium dense, measures frontal 1 cm., temporal .3 cm., occipital .8 cm.

Large amount of diploe. Scalp not unusual.

Dura mater not adherent to calvarium, slight thickening in frontal portion.

Few adhesions dura and pia over vertex and along longitudinal sinus. Few adhesions between tip of temporal lobes and dura. Lateral sinus of left side contains liquid blood, right side is filled with a firmly adherent clot. Pituitary soft.

Right ear drum thickened with one small perforation of the drum. Left slightly thickened.

Pia Mater slightly thickened notably over vessels over vertex.

Pons and cerebellum weigh 125.

Brain firm, with no marked atrophy of convolutions. Slight flattening in parietal region of right side, left hemisphere appears well rounded. Ependyma free and smooth, no sclerosis in basal vessels.

Brain weight 1215 grams.

Anatomical Diagnosis.

Well nourished.
Rigor mortis.
Unequal pupils.
Asymmetry.
Chronic peritonitis.
Chronic perisplenitis.
Enlarged mesenteric lymph nodes.
Uterus in dextraposition.
Chronic adhesive pleuritis of left lung.
Chronic epicarditis.
Chronic endocarditis.
Chronic aortic and mitral endocarditis.
Fibrous scars at apices of both lungs.
Acute bronchitis left.
Small spleen.
Acute gastritis.
Acute nephritis.
Enlarged retroperitoneal lymph nodes.
Uterus and ovaries atrophic.
Calvarium dense.
Perforation of right ear drum.
Slight chronic pachymeningitis.
Slight chronic leptomeningitis.
Brain weight 1215 grams.

c) Special Anatomical Description of Brain.

After preservation in formaldehyde, the following further description of brain was made: —

The brain is dolichocephalic in type. There is slight asymmetry particularly at the poles, the left in each case being more pointed, and the right occipital tip points away from the median line in a slight degree.

The pia is moderately thickened, and its vessels injected. There are many arachnoid villi along the superior longitudinal fissure. The convolutions throughout are rather narrow, but fairly well rounded, and moderately complex. There is slight opening of the sulci throughout.

The primary sulci of the frontal lobe are not clearly defined. The first can be traced with some difficulty, the line being broken and irregular. On the left it is interrupted by three annectants; on the right the walls interdigitate in a way to make it unclear. The remainder of both lobes is marked by generally transverse convolutions.

The precentral gyrus is continuous on the right; on the left it is cut across by the first frontal sulcus. The postcentral sulcus is very narrow. At about midway its length an annectant connects it with the inferior parietal lobule on both sides. The fissure of Rolando on both sides forms little less than a right angle with the superior longitudinal fissure. Their upper extremities cut the superior margin, and extend upon the mesial surface. The lower extremity on the left is separated from the fissure of Sylvius by the convolution forming the operculum; on the left it cuts through the operculum and extends into the Sylvian fissure.

The convolutions of the parietal lobes are narrow, and complex with very slight separation of their summits. On the right the parts of the interparietal sulcus are continuous; on the left they are interrupted by annectants and all three are separate.

The occipital lobes are not remarkable except for the slight asymmetry already noted.

(Mesial surfaces are not photographed.)

The only feature of the base of the brain worthy of note is the asymmetry of the pyriform lobules. The right is larger and considerably more prominent than the left.

The frontal sections show both lateral ventricles much dilated, except in the descending horns; the optic thalamus and the horizontal portion of the caudate nucleus are considerably flattened. The subiculum gyrus hippocampi also is much flattened and shrunken.

The cerebellum is notable only for the apparent lack of uniformity between the two dentate nuclei.

d) Microscopic Examination.

From the notes of a partial microscopic examination, the following is abstracted: —

The left and right prefrontal areas exhibit a marked gliosis with the appearance of a great numerical increase of cells in all layers. Many of these cells are of a type best described as shadow cells. The plexiform layer shows coarse glia fibers. The remainder of the frontal region exhibits identical changes.

In the white matter underlying both the left and right precentral gyri, there were many ganglion cells largely of the fusiform type ordinarily found in the undermost layer of the cortex. Although there were numerous corpora amylacea in the white matter, there was no gliosis and there was no alteration in blood vessels. The cortex of this region showed a slight degree of satellitosis with a slight subpial gliosis. There appeared to be a focal loss of nerve cells effected in various places of the laminae, except the layer of small pyramids. It is estimated that many Betz cells are smaller than normal. Their protoplasm is granular and there is marked increase of yellow pigment. There are frequent shrunken cells and shadow cells in all layers. The postcentral regions of the two sides are slightly better off as to cell shrinkage than the precentral gyri.

The intermediate postcentral regions also show a considerable degree of subpial gliosis and numerous corpora amylacea. Upon the right side there appears to be a thinning in the layer of large pyramidal cells upon the summit of the gyrus examined. There is no such finding upon the left side. There is a suggestion of increase in glia cells throughout the white substance underlying the intermediate post central gyri.

There is a slight gliosis in the white matter of the calcarine areas. Under the transverse temporal gyri are numerous dislocated ganglion cells in the white substance, resembling those mentioned under the precentral gyri.

The area of Broca shows cellular gliosis with corpora amylacea, a moderate degree of general nerve cell atrophy and a thinning out of the layer of internal large pyramids from the summits of the gyri examined. In the subpial layer are many coarse neuroglia fibers.

The hippocampal gyri, cornu ammonis and pyriform lobules show an unusual degree of subpial gliosis and infiltration of corpora amylacea. There is also a gliosis under the ependyma of the ventricles sectioned at this point. There were a number of cells staining palely with colorless spaces about the nucleus, including some shrunken cells with non-staining nuclei and elsewhere were some examples of the shadow cells above mentioned. There is occasional satellitosis but not confined to special laminae.

The spinal cord and medulla show a marked fibrillar gliosis of the periphery and about the central canal. The posterior columns show a considerable infiltration of corpora amylacea. There appears to be a degree of perivascular infiltration in the posterior fissure.

e) Anatomical and Histological Summary.

The brain of this case shows an atrophy or aplasia of the type with flaring sulci suggestive of a condition in which the white matter is relatively better preserved than the grey. The left side appears slightly more hypoplastic or atrophic than the right. The parietal lobes exhibit particularly narrow convolutions and may indicate a certain tendency to microgyria. The left pyriform lobule is smaller than the right. (This appears accordingly not to be a case of cruciate asymmetry in the sense of case V, for example.)

Employing the microscopic examination for the purpose of determining whether this case is one of acquired lesion, we find a marked gliosis with apparent great numerical increase of cells in many layers. We find a coarse fibrillar gliosis of the plexiform layer in places. We find a considerable variation in degree of gliosis in different places but these findings are consistent enough with the hypothesis of relatively recent changes in a subject of 62 years.

Likewise we may logically dispose of the satellitosis found in certain places as well as the over-pigmentation of certain nerve cells. The shrunken nerve cells, so-called shadow cells, are consistent enough with the hypothesis of relatively recent chronic change. In fact, we should probably be at a loss to determine whether there was any evidence of fundamental change suggestive of long-standing lesion if it were not for the dislocated ganglion cells in the white matter in certain regions. It is important to raise the question whether the slight degree of perivascular infiltration in the posterior fissure of spinal cord in places is to be regarded as a sign of old syphilis. The suspicion must at least be raised in the case, although the data of Wassermann reaction are not available. There are in the body at large no special signs indicative of old syphilis (enlargement of mesenteric and retroperitoneal lymph nodes, valvular and parietal endocarditis, etc.).

The case is of peculiar value in emphasizing the difficulties which attend a decision as to inborn and acquired lesions in cases of elderly subjects. Of course the majority of the feeble-minded fail to reach the sixties, possibly for reasons inherent in their general make-up. This case then must be used as a limiting instance in our total larger series.

Synopsis of Findings in Case V.

a) Clinical.

Case V has been already published in Southard's monograph on dementia praecox, from which the following condensed history is taken:

C. B. was a boy of 15 when he was committed to D. S. H., and died there a year and four months later of *typhoid fever, ulceration, and peritonitis.* The mental diagnosis was eventually considered to be *dementia praecox.*

Mother nervous and melancholy during her pregnancy with this boy; hard usage and neglect by husband complicated the pregnancy. From an accident to the boy at seven, is said to date a change of character, with refusal to go to school, fretfulness, and nervousness. At 14 another accident to back and head. An inmate of a truant school for two periods of three and two years respectively. Uncle a patient at state farm.

Auditory hallucinations, refusal to eat, nervousness, and certain delusions antedated commitment by only a week. (Masturbation had begun four or five months before, but had probably ceased.) Insomnia is said to have lasted four nights after onset. *Food poisoned. Passers-by or Indians were to kill him* (given to blood-and-thunder stories). *"Had never done anything to gladden America," "Traitor," "Going to be shot."*

Cyanosis of hands; gait staggering (no Romberg); right cremasteric reflex not active.

After eight months' observation it was thought that the patient really belonged in the moron or subnormal group of defectives, and in the quasi-criminal class. A little over 11 months after the delusional episode upon which he was committed, patient developed a spell of disturbance which lasted 10 days. In this spell, patient was noisy, threatening, profane, denudative, given to disconnected and incoherent talking, lost weight and grew pale. Almost three weeks later typhoid fever developed, and death followed from peritonitis.

b) Autopsy.

Summary.— Aside from the typhoid fever lesions, there were bronzing of skin, unusually small adrenals (questionable glycosuria had appeared on entrance but later disappeared), a small thyroid, slight sclerosis of aorta and right auricular endocarditis; cardiac hypertrophy, chronic myocarditis, pleuritis, and pericarditis.

The brain weighed 1435 grams (over weight 90 grams by Tigges' formula). There is nevertheless a tendency to *frontal atrophy*, perhaps more marked on *left* side. Striking anomalous folding of convolutions in both calloso-marginal regions above the splenium; but on the left side the fissuration suggests acquired lesion rather than congenital anomaly (region above and behind the rostrum).

c) Special Anatomical Description of Brain.

After hardening in formaldehyde, the following further description of the brain was made:

Measurements: Length left hemicerebrum,	LLH,	18. cm.
right	LRH,	18. cm.
Greatest width W–L.,		6.5 cm.
Rt.,		7. cm.
Height, Heit		10.75 cm.
Arc frontal pole to Rolando, left,		10. cm.
right,		10. cm.
Distance temporal to frontal tip, left,		4.5 cm.
right,		5. cm.

The specimen shows the not unusual frontal and occipital cruciate asymmetry, in which the frontal lobe, particularly the most anterior portion, and the contralateral occipital lobe, are narrower than their fellows. In this case it applies to the left frontal and right occipital lobes.

There is slight general clouding of the pia over the vertex, somewhat more extreme near the margin of the longitudinal fissure. The pial vessels are moderately injected.

With the pia removed the convolutions appear in general fairly well rounded, but rather narrow; their summits are not closely approximated. There is no remarkable lack of complexity.

The frontal convolutions are distinctly separated from each other by longitudinal sulci, though an annectant connects the middle of the first with the base of the second on both sides. The third is noticeably prominent on the left.

In the central area the Rolandic fissures leave the superior margin of the hemisphere at a right angle. At the superior knee the right points forward more than the left, but the lower extremities both end at a point 7 cm. from the frontal tip. The upper extremity of Rolando extends onto the mesial surface 1.5 cm. in a backward direction on the left, 0.5 cm. perpendicularly on the right. The post central convolution is slightly narrowed in its upper extremity. In the parietal lobes the post central sulcus forms a second or double Rolandic fissure. Posterior to this one the usual interparietal sulci, with the horizontal and descending branch.

The occipital lobes are small; the left side is not otherwise notable, but on the right side the second gyrus is narrowed and shrunken, causing a drawing in of the surface, a part of which is consequently depressed below the surrounding area. On lateral view this forms a slight concavity in the surface of the occipital lobe.

The basal surface of the brain shows no marked anomalies. The collateral sulcus on the left is interrupted about midway by an annectant between it and the fourth temporal convolution. The typical H-shaped sulcation on the orbital surface is absent; the fissures are mainly sagittal in direction, and near the lateral margin, leaving the middle orbital gyrus unusually wide. The lateral view of the region shows the so-called "keel-formation" of the *gyri recti*.

The mesial surfaces of the hemispheres are striking particularly on account of the unusual similarity in their configuration. The cuneate lobule on the left is somewhat smaller than that on the right.

The corpus callosum is slightly thinned in its posterior half.

There is no middle commissure.

Gross frontal sections show the cortex of fair and uniform width throughout.

There is some apparent atrophy at the anterior temporo-insular junction, which leaves the adjacent parts unapproximated.

The cavity of the right lateral ventricle is larger in all its diameters than that on the left, although the difference is only moderate in degree.

There is nothing remarkable about the basal nuclei or the subthalamic structures.

d) Microscopic Examination.

The Weigert-Myelin sheath preparations show good fiber connections in all areas examined. Comparisons were made with the drawings in Campbell's "Localization in Cerebral Function." Evidences of gliosis were as follows: —

The prefrontal tissue shows a moderate increase in the plexiform layer, involving not only an increase in a number of cells but in the number of fibrils. There is no gliosis elsewhere. Although there are frequent ganglion cells in the white matter, there is no notable neuroglia increase in this locus. The prefrontal region showed occasional bi-nucleate neuroglia cells supplied with fibrils in the plexiform layer; but there is no marked gliosis elsewhere.

The same description fits the postcentral tissue, except that there are groups of satellite cells in various layers (right postcentral) as a rule surrounding the small nerve cells.

The superior and inferior parietal regions show similar glia pictures in the plexiform layer. From the standpoint of gliosis, accordingly, the cerebral cortex of this case exhibits in all areas, so far as examined, a moderate degree of cellular and fibrillar gliosis of the plexiform or subpial layer, but fails to show gliosis in other layers, except in the specimens examined from the right postcentral region.

As against the neuroglia picture, we may consider the nerve cell pictures. Of course the excellent preservation of the fiber connections as above noted would indicate that there should be no extensive degree of cell loss. What has so far been found may be summed up as follows:

The prefrontal region (for example, on the right side) shows a suggestion of thinning out of the nerve cells in the supragranular layers; at the summit of the gyrus the cells here are often small and deeply stained.

The large pyramidal cells of the infragranular region seem also thinned out. Similar slight degrees of thinning out of the cells are found in the supragranular pyramidal layers of the precentral region (upper portion right side); identical findings in lesser degree in the postcentral region and in larger degree of the superior parietal and inferior parietal regions. On the whole, the evidence of nerve cell loss or absence is distinct but slight. On the whole the supragranular layers appear to be more involved in this cell loss or absence than the infragranular layers. It is to be noted also that no important degree of satellitosis accompanies this cell loss, if we except the area examined from the right postcentral region.

A common finding in numerous areas is the presence of dislocated ganglion cells in the white matter. These were noted as frequent in right upper precentral, right postcentral, right inferior parietal, right superior frontal, and right prefrontal areas.

As for acute changes there was apparently a degree of chromatolysis in the larger cells in the frontal region, but not elsewhere.

e) Anatomical and Histological Summary.

Frontal and occipital cruciate asymmetry suggest inborn or very early acquired lesion. This case may well have been one of Dementia Praecox grafted upon a subnormal or moron condition and the microscopy is accordingly of interest. As in the previous case, (IV), so here there are frequent dislocated ganglion cells in the white matter. The gliosis and satellitosis of irregular distribution are con-

sistent enough with the hypothesis of acquired lesion. Nerve cell loss might be interpreted in either direction as due to fundamental absence or to early or late degeneration. In various places, the supra granular layers are subject to thinning out without any important degree of satellitosis (exception right post central region). Our best argument therefore for inborn lesion is the dislocated ganglion cells in the white matter, with the thinning out of cells in the supragranular layers as a not very strong secondary argument. Of course it has sometimes been held that satellitosis should be found alongside the cell loss in Dementia Praecox. Special studies in another series of cases, to be published in the Transactions of the Association of American Physicians for 1916, indicate, however, that cell loss and satellitosis do not necessarily proceed *pari passu* and that, in point of fact, in not infrequent instances, the cell loss proceeds independently of reaction. In some instances, it might be argued that the tissues passed through a phase of satellitosis followed by a phase in which nothing but cell loss can be demonstrated. An argument of this nature has been submitted in a paper published in the above mentioned Transactions for 1915. At any rate, it would probably be agreed by all that in Senile Dementia there are cases in which nerve cells slowly disappear without neuroglia reaction. The present case must therefore be used as another instance of the fundamental difficulty which attends a decision as to whether a case is one of primary or secondary amentia, even when a comparatively full anatomical and microscopic analysis is available.

Synopsis in Findings of Case VI.

a) Clinical.

1. **Physical Examination.**— Born in 1887; died Oct. 19, 1913. Slightly microcephalic; tall and rather slight; death from pulmonary tuberculosis. Further data are given in the description of the autopsy, below, in which the following features are of interest from the point of view of the pathological anatomist. The number of scars of "tissue paper" appearance over extremities, back, and head, suggested syphilis. There were also numerous superficially palpable lymphnodes; mal-formed ears; prominent mastoid processes; high palatine arch; asymmetry of face, especially of nose and jaw; under developed hands and genitalia; redundant prepuce; absence of right vocal cord; hypoplastic aorta, and accessory spleens. No history of epilepsy.

2. **Family History.**— Unknown. There is some suspicion of syphilis in the father, but the suspicion has not been well established. Patient had been three years in almshouse at Tewksbury before admission to the Massachusetts School, May 27, 1893.

3. **Personal Developmental History.**— Is said to have had measles. At time of application, at 6 years of age, he is said to have just begun to talk, and as understanding a good deal of what was said to him. Patient is described as very restless and nervous; is usually rushing around; inclined to be destructive, especially of cloth; soils and wets himself several times a day and every night. He would spend his time destroying shirtsleeves and coatsleeves, unravelling his stockings, and the like.

4 and 5 and 6. **School Progress and Examinations. Practical Knowledge.**— Progress at the Massachusetts School was slight. Patient was placed in the training classes but did not advance much. He was able to do simple outdoor manual work. (He could help to clear land, use grubhoe, dig up stones, and the like, and was able to polish floors and carry bundles.) Was able to feed himself with a spoon although he spilled much of the food. Needed to be helped in dressing and undressing.

7. **Economic Efficiency.**— Nil.

8. **Social History and Reactions.**— Unable to speak words. Made curious squeaking attempts at speech if people that he liked were about him.

9. **Moral Reactions.**— If something patient did happened to annoy the caretakers, patient seemed to take pleasure in their annoyance. Patient had the typical idiotic grin when spoken to.

10. Psychological Tests.— Approximately 2. This case, by reason of his aphasia (compare absence of one vocal cord), yielded a poorer impression of his capacity than was perhaps justified. In some respects, patient appears to have been above the rank of idiocy and to fit into the lower grade of imbecility.

Waverley School History.— Patient's tuberculosis resisted outoor treatment.

b) Autopsy.

Body.— That of a slenderly built emaciated white male 158 cm. in length. The *skin* is bluish gray, and abrasions occur over elbows, hands and shins, irregularly. There are also quantities of "tissue paper" *scars* over lower legs and back and scalp varying in size from 0.8–1.5 cm. in diameter. *Lymph nodes* palpable in neck and groins. *Rigor mortis* absent, no body heat. Decomposition bands in flanks.

The head is markedly out of proportion, being long and narrow (occipitomental 56 cm.) the *ears* flare and the measurement from superior portion of helix to lobule inclusive is 5.5 cm. × 4.0 cm. from tragus to lateral side of helix, with a wide and flat antitragus and a minute tragus. Mastoid processes unduly prominent. *Palatine arch* high, teeth in fair condition. *Nose* is deflected to right and the angle of the lower jaw on this side is markedly prominent, the line of the left being longer and the angle less noticeable. The *hands* appear larger than would be proportionate with the arms, and the finger nails are minute, measuring 0.6 cm. in height showing evidences of much nibbling and the eminences below the thumb are absent — giving the palmar surfaces a remarkably undeveloped appearance. Legs not notable. *Genitals:* The scrotum short and broad, extending in direction of but not reaching anal surface. Penis short and thick. Prepuce long, glands very red. No edema; a decubitus measuring 0.4 cm. over sacrum is fairly superficial.

Ventral section.— Panniculus nil. Muscles red, peritoneum shows post mortem change. Omeutnm contains no fat, transverse colon extends in a V-shape with apex downward into pelvic cavity. Stomach 14 cm., *liver* 8.0 cm. below costal margin. *Spleen* free; *mesenteric lymph nodes* remarkable in size and number, some measuring 3 cm. in length. Appendix 8.0 cm. in length — has a mesentery of its own. Prostate not enlarged, no free fluid in the cavity. Diaphragm arches to the 3d interspace on the right, the 4th on the left.

Thorax.— Mammary vessels not sclerosed, sternum measures 3.0 cm. on frontal aspect, 5.5 cm. on visceral. Bone marrow of sternum rich red, smears stained show excess of eosinophiles and few giant cells. No nucleated red cells.

Pleuric cavities obliterated at apices, anterior edges of lungs overlap in median line: pericardium not thickened.

Heart.— (No weights taken), estimated 250 grams. No fat in epicardium. Myocardium greenish red (p. m.). Coronaries show no change. Section shows right auricle and ventricle filled with cruor clot. Myocardium *elastic*, not friable.

Measurements: T. V., 13.0 cm. P. V., 6.0 cm. L. V., 1.0 cm.
M. V., 10.0 cm. A. V., 6.5 cm. R. V., 0.4 cm.

Endocardium not remarkable. Some slight thickening in aortic cusps below corpus aurantii.

Lungs.— Not weighed. Over surface of left there are areas which show as slightly umbilicated centrally, red edges measuring 0.4 cm. Cut section shows a spongy parenchyma, with thickened bronchi in the lower portion and a gush of yellowish puriform material follows knife cut at apex. Stained smear shows tubercle bacilli in countless numbers.

Same process in right lung, possibly more extensive. Peribronchial lymph nodes not remarkable and showed no areas of infiltration on section.

Organs of the neck.— The tongue is heavily coated. The epiglottis is thick and yellowish and bathed in pus. The aryteno-epiglottidean folds are ragged on their free edges. From above superior and

inferior vocal cords appear unequal, and on section there are none on the right, being replaced by small white nodes which extend over the whole cavity of the larynx above the cord district. On the left a ventricle is the only mark by which a superior and inferior vocal cord may be inferred. *Thyroid* not notable. No thymus nor parathyroids seen. *Aorta* is remarkably narrow (3.5 cm. in circumference) and very elastic.

Abdomen.— *Spleen* not weighed. Estimated weight 100 grams. Somewhat autolysed, capsule not thickened. Pulp soft, trabeculae and malpighian bodies not notable. On the inferior edge two small accessory spleens hang, one is 0.2 cm., another 0.8 cm. in diameter.

Adrenals.— Remarkably small, not over 1.5 cm. at the widest part on cut section.

Kidneys.— Not weighed — estimated 200 grams. No perirenal fat; capsule stringy and non-adherent, cortex swells slightly over capsule, color of medulla and cortex homogeneous (from p. m. change). Pelves not notable.

Liver.— Not weighed — estimated 1500 grams. Capsule not thickened. Streaks of yellow occur on surface, organ friable but holds its own weight, inferior edges sharp. No stone in gall-bladder.

Pancreas.— Not examined.

Gastro-intestinal tract.— Not examined. Were deep greenish red from post-mortem change.

Genito-urinary tract.— Prostrate not enlarged. Bladder contains some heavy purulent material. Testis threads well.

Head.— Hair black and short; scalp adherent. Calvarium is well supplied with diploe but has curious inequalities in thickness; frontal measures 0.8–1.0 cm., temporal 0.2–0.8 cm. (in strikingly irregular alternations), occipital 0.9 cm. The dura is not adherent except along the superior longitudinal sinus, and is thickened only along the middle meningeal distribution and the convolutions are plainly seen through it. *Pia mater* is exceedingly thin and delicate, without edema; the twigs of the arterial capillaries are very brilliantly outlined. There are but two large veins on the vertex, these correspond very nearly to fissure of Rolando and are distended. The hemispheres are apparently equal in size with the exception of a bilobed occipital lobe on the right. There seems to be no cerebrospinal fluid. The *brain sags* on a board and tends to assume a nearly round mass. The *convolutional* pattern is simple and the sulci *shallow*, particularly is this so on the *right*, involving the motor and parietal lobule, and seeming to limit the frontal pole, the left parietal lobule having a more complex configuration and the frontal pole a greater extension. Smear from this portion shows striking loss of nerve cells; and infiltration of vessel walls with lymphocytes and polynuclear cells.

At the base.— The 2nd left temporal convolution at the tip has a yellow and denuded look under the pia and is somewhat firmer to the touch. Question of tubercle. Smear from this portion shows cellular detritus. No organisms.

The denuded area on the right temporal tip is artefact. The *basal vessels* are slightly hazy but no buds nor abnormal branching of arteries seen. The *pia* at base binds the 3rd and 4th nerves to the anterior perforated space. *Cerebellum* slightly softened, the olivary bodies are fairly firm as are the occipital tips. Remainder of brain (with exception noted) fairly normal in consistence. Pituitary pigmented on section. Ganglions negative. Petrous portion temporal bone thick. Left ear drum has a hole 0.3 cm. in diameter in its center with white and indurated edges, and smear shows tubercle bacilli. Right negative. Optic nerves show brilliant injection of retinal arteries with question of blurred outline of nerve head. There are irregularities in bone in the middle meningeal distribution. Brain weight, 1130 grams.

Cord.— Not notable.

Anatomical Diagnosis.

Emaciation.
Abrasions over extremities.
?Syphilitic scars over extremities and back.
Scars over head.
Palpable lymphnodes (superficial).
Dolichocephalic head.
Malformed ears.
Prominence of mastoid.
Palatine arch high.
Asymmetry face (nose and jaw).
Nails nibbled below the mid line.
Hands undeveloped.
Redundant prepuce.
Genitals undeveloped.
Decubitus superficial (sacral).
Gastroptosis.
Splanchnoptosis.
Lymphnodes large and prominent (reversion?).
Chronic fibrous pleuritis.
Pulmonary tuberculosis.
Slight chronic fibrous endocarditis (aortic valve).
Tuberculous epiglottis.
Tuberculous aryteno-epiglotidean folds.
?Aplasia vocal cords.
?Tuberculosis of vocal cords.
Small aorta.
Autolysis of spleen.
Accessory spleens.
Small adrenals.
Slight acute parenchymatous nephritis.
Cystitis.
Calvarium unequal in thickness.
Calvarium brittle.
Focal chronic pachymeningitis.
Slight anomaly right occipital tip.
?Hydrocephalus.
Inequality of convolutional pattern, particularly right side.
Slight basal leptomeningitis.
Tuberculous ulcer left ear drum.
Pigmentation of pituitary.
?Choked discs.
Brain weight: 1130 grams.

c) Special Anatomical Description of Brain.

The brain is symmetrical; the frontal lobes small and pointed; the occipital lobes short, and their tips point away from the median line.

The pia is generally slightly thickened, with numerous arachnoid villi along the superior longitudinal fissure on both sides. The pial vessels are moderately injected, including the capillaries.

The convolutions throughout are broad, well-rounded, and there is a noticeable lack of complexity.

In the right frontal lobe, the first convolution is much narrower than the second or third; the two latter are not clearly defined, and are very scantily fissured. On the left there are apparently four longitudinal divisions, and each is somewhat more complex than on the right. The third left frontal is not remarkable.

The central convolutions are of good width, and well-rounded. The precentral is connected about midway its length with the base of the second frontal by a recurved annectant. The postcentral convolution is narrow at its upper extremity on both sides, and again at the junction of the middle and lower thirds on the right. The fissure of Rolando forms little less than a right angle with the superior longitudinal fissure. Its upper extremity cuts the superior margin on the left and on the right extends well over on the mesial surface. The lower extremity cuts the operculum on both sides and is lost in the Sylvian fissure.

The parietal lobes are marked by a very irregular pattern. The sulci are generally arranged in a transverse direction. The superior parietal lobules are broad; the right one somewhat more so than the left, and both present very few secondary fissures.

The sulcal pattern of the temporal lobes is rather irregular; on the right the superior gyrus is narrow

and loosely convoluted. The superior sulcus is distinct and complete. The second convolution is broad with very few fissures, and these are confined mainly to the posterior part of the gyrus. On the left the limiting sulci are indistinct, but on the whole the fissure-complex is less simple.

Of the mesial surfaces, the right is more complex; the cuneate lobule is larger and presents more fissures. The right calloso-marginal fissure is complete from its subrostral origin to the marginal extremity, while on the left it is interrupted several times by annectants. The corpus callosum is thin throughout its entire length.

The most evident peculiarity of the orbital surfaces is the difference in width of the gyri recti. The right is nearly twice as broad as the left, and extends beyond the median line to the extent that its midpoint corresponds in position to that of the optic chiasm.

The pyriform lobules are nearly uniform in size; the collateral fissure is continuous with the fissura rhinica on the right, but fails to join on the left. Altogether the left temporal lobe presents the appearance of better development than the right.

Frontal sections show no focal lesions. The cortex is of fair width, and the white matter comparatively small in amount. All the sulci in the temporal lobe are deep, and the gyri narrow, finger-like processes.

There is no enlargement of the ventricles, nor other anomaly apparent.

d) Microscopic Examination.

From the partial microscopic examination, the following is abstracted:

The findings in numerous areas yield a somewhat general picture. There is, as a rule, an increase of neuroglia cells in the white substance. Even the vessels are lined by an accumulation of neuroglia cells. There is a considerable satellitosis in all layers, including the plexiform layer, but there is no tendency to an excess of gliosis in the plexiform layer. There is a tendency to decrease of nerve cells so far as qualitative estimate can suffice in the diagnosis in most areas. The frontal areas show a smaller degree of scarcity of cells than numerous other areas. On the whole, the qualitative estimate of neuroglia cell increase rather indicates that the left side is more affected than the right (for example, left insula, left superior parietal, left pyriform lobule, left transverse temporal).

The findings of particular interest are as follows: — First, rod cells in the cortex of the right upper post central region, a region which also shows a moderate degree of cellular gliosis in the white matter; but this latter gliosis was characterized by the presence of a great many glia nuclei of unusual shape. The area showed very general thinning out of the cells in all layers, particularly at the summit of the gyrus. Frequently cells are found with an appearance of degeneration. Rod cells are also found in the right pyriform lobule.

Secondly; the finding of one large vessel in the right precentral region surrounded by a relatively heavy collection of lymphocytes; other vessels show numbers of green pigment-laden phagocytes. This area shows considerable satellitosis in all layers; the satellite cells are particularly noteworthy about the large pyramidal cells. There is an increase in neuroglia cells in the plexiform layer with a focal tendency. Of course in connection with a suspicion of brain syphilis, which we may consider proper to raise in connection with the lymphocytosis above noted, especial attention was given to the observation of other foci of lymphocytosis. Several other examples of infiltrated blood vessels were found in the frontal region and with a tendency to accretions in the vertical region.

e) Anatomical and Histological Summary.

This brain of simple construction (1130 grams) is comparatively symmetrical. Its corpus callosum is thinned throughout. The white matter of the centrum semi ovale is comparatively small in amount. It does not appear that the ventricles are enlarged. Microscopically once more we discover a marked

gliosis, with considerable satellitosis corresponding with a certain decrease of nerve cells, if we may judge qualitatively of such loss. On the whole the left side is slightly more affected than the right. We raised the hypothesis in Case IV as to old syphilis, basing our suggestion upon the presence of the effects of perivascular infiltration in posterior fissure of the spinal cord. If we follow the same line of argument in Case VI, we should call attention to the effects of lymphocytosis about a large vessel in the right precentral region. The presence of rod cells in the cortex of the right upper post central region as well as in the right pyriform lobule may perhaps be regarded as evidence running somewhat in the same direction. These rod cells are characteristic of certain cases of General Paresis, although neuropathologists do not customarily make a diagnosis of brain syphilis upon the presence of rod cells. It may be that both the focal lymphocytosis and the occurrence of rod cells are based upon some other condition than syphilis, but at all events, the lesions are of an acquired nature and go to indicate the presence of at least a slight degree of active chronic, inflammatory processes. It is possible to think of tuberculosis as responsible for the lymphocytosis and it may be for the rod cell deposits, since this case showed widely distributed tuberculosis, pulmonary, epiglottis, vocal cords, left ear drum, etc. A review of the anatomical diagnoses in the case will show the presence of numerous stigmata.

Synopsis of Findings in Case VII.

a) Clinical.

1. Physical Examination.— At 15 years of age, patient was five feet tall and weighed 97½ pounds. She was born May 5, 1888, and died March 17, 1914. Patient is described as undersized, poorly nourished, anaemic, slightly deaf; as having a small cranium, with circumference of 19¾ inches, and cephalic index of 84. The face was asymmetrical, the eyes closely set, the teeth irregular, the palate high, and narrow arch. From the autopsy report, given in full below, the following features are culled: Absence of axillary hair, anomalous distribution of pubic hair, rudimentary left nipple, anomaly of toes, deflection of nose to left, dental ridges (mal-nutrition?), ovaries very large, anomaly of kidney; anomaly of sympathetic gangliated cord.

2. Family History.— Patient's father was born in New York City, of French extraction; the mother was born in England. The father was 37 years old at the birth of the child; the mother was 42, and had had four children before the birth of the present case. Three of the children had died before 1893: two girls, described as dying of marasmus, and one boy as dying of croup at the age of 5 years. It is stated that there was no deformity of body or mental deficiency in the other children. The mother is described as never having been very strong, and as subject to fainting fits. She is stated to have been in excellent health until the sudden death of the boy above mentioned, which death took place when she was 7 months pregnant with the present patient.. The mother states that she fell off a small box 24 hours before delivery, and that the patient was born at 8 months. An aunt of the patient, the mother's oldest sister, is stated to have become paralyzed at the age of 24 years, and remained in this paralyzed condition until her death, at 42, of consumption.

3. Personal Developmental History.— The patient was carried on a pillow for a year, as she could not hold her head up. Patient began to walk at 3½ years, and became very active. At 5 years, a few words, such as "ma," "pa," "money," "goodbye," "bad boy," were said. The patient is described as having tried very hard to say more words but as being unable to shape them. When desiring to attract attention to something, she would say "Bookit." At the age of 5, she had learned to use a spoon and fork, and kept her person clean. She was restless in sleep. There was a history of middle ear disease on both sides in early childhood. Patient was a mouth-breather, with large tonsils.

4 and 5. School Progress and Examinations.— Patient upon admission was unable to take the regular school work and was placed in the training classes; although kept in these classes for several

years, she made very little advance. She learned to march in step and could play very simple games. She could not be taught to match color and form.

6. **Practical Knowledge.**— When admitted to the school, the patient was untidy, but became thoroughly tidy after training. She was able to feed herself, and to dress and undress herself, although careless with the clothing and inclined to be destructive thereof. Patient learned to do simple work with the hands, such as cutting paper and cloth, but could not cut to a line.

7. **Economic Efficiency.**— Nil. Patient was able to do simple domestic work, such as dusting and rubbing the floor, and could make a bed with help.

8. **Social History and Reactions.**— Patient would often walk towards a person as if about to speak, and then draw back, repeating this action several times in succession. When excited, patient would jump up and down and scream, whether pleased or displeased, and would laugh and cry at the same time.

9. **Moral Reactions.**— Patient is described as having been of a good temper during her Waverley School life. She was fond of music and liked to look at picturebooks. Was apparently perfectly happy if given a doll or other toy. She was particular about food, liking goodies. She was always rather excitable and noisy, and interpretation of her emotion was difficult on account of the identity of reactions when pleased or displeased. Patient gave the impression of laughing and crying at the same time. Patient masturbated.

10. **Psychological Tests.**— Patient's mental age was 5 years.

Waverley School History.— Patient was admitted to the school, June 20, 1895, and after remaining a few months, was taken home by her mother. She was re-admitted in 1896, at the age of 8 years. She was very seldom sick at the school, dragged her feet, and stood and sat in a roundshouldered attitude. She would march in step if some one put hands on her shoulders in the proper way. Patient is described as running about in a lackadaisical manner, and as having a habit of skipping with one foot. She played relay races well, but was unable to see the point of some of the simple circle games. Patient was addicted to talking, and was more or less troublesome. She showed a number of peculiar movements; for example, she would roll and pick the front of her dress with her hands, and finish the process by holding a bunch of clothing in her left hand, passing her right hand in circles over her head. Another characteristic action was pointing her finger downward with arm extended, and repetition of "Yah, mamma, yah." Now and then she would shake her head and squint her eyes. Toward the close of life she had lost much weight and apparently also in height. Tuberculosis was made out in March, 1914, just before her death, involving the entire left lung and right apex.

b) Autopsy.

Autopsy.— Head, trunk and cord, Dr. M. M. Canavan.

Body.— That of a somewhat *emaciated*, slender white female, 146 cm. in length. Skin *waxy yellow white* in color. There is an *abrasion* over the right cheek, punctate in character, 2 cm. in diameter. No decubitus scars, edema, nor palpable lymph nodes. *Axillary hair* absent, *pubic hair*, yellow, grows in an eliptoid manner 4 cm. above the symphysis, and cylindrically over the labia majora. *Left nipple* appears rudimentary. 3d and 4th *toes* on both feet much shorter than 1st or 2nd.

Abdomen distended and gives hollow note on percussion.

Pupils equal, 0.3 cm. Nose deflected slightly to left. *Upper teeth* slightly uneven, (suggestion of early nutrition disease) ridged, but no trace of uneven cutting edge. Orbital arches flattened, forehead measures 8 cm. in height above them and is a straight, not a curved line.

Ventral section.— *Panniculus* nil. *Muscles* in remarkable rigor. *Peritoneum* shining and grey. *Stomach* 20 cm., *Liver* 11 cm. below ensiform. *Spleen* large and free from adhesions. *Appendix* 5.5 cm. in length, somewhat injected, has a mesentery of its own. *Mesenteric lymph nodes* not enlarged. *Ad-*

hesions exist between lower inferior edge of liver and the transverse and ascending colon. Some free fluid — estimated 150 cc. thin and pale in color exists in peritoneal cavity.

Pelvis.— The uterus, 5 cm. in length, is in an anterior position; the right ovary measures 5 × 2.5 × 1.0 cm.; the left ovary measures 3 × 1.5 × 1.0 cm.

Diaphragm.— Reaches to the 5th interspace on right, to the 6th rib on left. Ribs are remarkably close together — hardly an intercostal space that was more than 0.5 cm. in width.

Thorax.— Lungs adhere to chest wall closely showing on the right a yellow puriform open space, and the left is evenly consolidated on palpation with recent fibrin at apex. Lungs not removed but cut in situ with the cavitation of right apex seen: it is extensive.

Heart.— Assumes circular form — epicardial fat scant — coronaries small — not sclerosed. Myocardium grey white. Endocardium not notable.

Valve measurements: T V, 10.0 cm. P V, 6.0 cm. L V, 1.0 cm.
M V, 9.0 " A V, 5.0 " R V, 0.5 "

The aortic valve is miniature in size of leaflets, and there is some sclerosis of the origins of the coronaries. The arch of the aorta is smooth — diameter of arch 2.0 cm.

Organs of neck.— Not removed.

Abdomen: Spleen.— 13 × 9 × 3 cm. Markedly large; trabeculae distinct — pulp slightly watery and pale. No Malpighian bodies.

Adrenals.— None seen.

Kidneys.— Right much smaller than left; contains only three pyramids. Capsule thick, cortex pale and does not show injection. Pelvis very large — somewhat injected.

Liver.— Somewhat large. Capsule of Glisson is thickened, inferior edges fairly blunt. Color red-brown. Nothing of note on section. Gall-bladder wall white and edematous. No stones.

Pancreas.— Not examined.

Gastro-intestinal tract.— Stomach large and distended. Rugae not present. Intestines negative throughout.

Genito-urinary tract.— Ovaries contain pigmented scars — (has not menstruated for a year).

Retroperitoneal tissues.— Peripheral nerves negative. Sympathetic chain seems vastly broken up into fine threads.

Head.— *Hair* fine and abundant if short. Scalp pale, scanty in fat. *Temporal muscles* fairly well developed. Calvarium 0.3 cm. frontal, 0.1–0.3 cm. temporal, 0.4 cm. occipital; it is very dense and eburnated; no diploe. At the junction of the coronal and sagittal sutures the *dura* is markedly adherent (the brain herniating through small points of cut dura on forcible removal) and the dura is thickened from this central point to the area of middle meningeal distribution. Vertex is ball shaped and small. *Pia mater* is thin and delicate except over sulci and vertex where faint hazing appears.

Hemispheres equal but appear very shortened in the frontal portion as though the whole prefrontal area were missing. *Convolutions* are simple and shallow, running with no complexity to the longitudinal sinus. *Post rolandic* gyri simple in pattern. No inequalities on palpation. At the *base* the temporal lobes are exceedingly *plump*, and make the distance between their free edges and the frontal pole appear very short.

Basal arteries clear.

Optic and 3d nerves negative.

Gasserian ganglions negative.

Pituitary softened. Middle ears — left drum ruptured, right not seen.

Cerebellum, pons and cord negative.

Brain weight, 1270 gms.

Anatomical Diagnosis.

Emaciation.
Abrasion of right cheek.
Absence of axillary hair.
Anomaly pubic hair.
Rudimentary left nipple.
Anomaly of toes.
Distention of abdomen.
Nose deflected to left.
Malnutrition ridges on teeth.
Forehead high and flat.
Splanchnoptosis.
Slight injection of appendix.
Chronic peri-colitis.
Slight ascites.
Ovaries very large.
Ribs closely set.
Chronic adhesive pleuritis.
Pulmonary tuberculosis, (advanced).
Cloudy swelling of heart muscles.
Right heart hypertrophy.
Aortic stenosis.
Anomalous kidney.
Chronic perihepatitis.
Chronic cholecystitis.
Anomalous sympathetic ganglionated cord.
Calvarium dense.
Chronic external adhesive pachymeningitis (focal).
Chronic fibrous pachymeningitis — (middle meningeal).
Slight chronic leptomeningitis sulcal and vertex.
Anomalous frontal poles (shortening).
Simplicity of convolutions.

c) Special Anatomical Description of Brain.

A more detailed description of the brain is as follows: — The brain is of fair size and suits the dolichocephalic type of skull. The dura mater was attached rather more firmly than usual to the pia mater and the brain by means of numerous pial vessels and their investments. There is no evidence of arteriosclerosis. The pia mater is everywhere slightly thickened and of a dull, cloudy appearance.

There is slight asymmetry of the two hemispheres; the right is shorter than the left, and the right occipital lobe points away from the median line. The convolutions are everywhere of fair width and usually well rounded and approximated.

In the frontal lobe, the dividing sulci are distinct. On both sides the first sulcus cuts across the precentral gyrus. The second frontal gyrus is broader than the first on both sides.

The central convolutions are quite narrow, the postcentral notably so.

The pattern of the parietal lobes is in general transverse in direction; the interparietal sulci are interrupted by an annectant between the postcentral gyrus and the superior parietal lobule on both sides. This leaves the ascending postcentral sulcus separate from the descending portion and the horizontal branch. On the right, at the junction of the descending and horizontal interparietal sulci, there is a distinct rosette formation. The size of the two parietal lobules, superior and inferior, is nearly the same on both sides.

The occipital surfaces are not notable except for the slight asymmetry already remarked upon.

On the base of the brain the orbital surface presents the usual triradiate sulcal pattern.

The collateral fissure on both sides is continuous with the fissura rhinica (Turner), thus separating the pyriform lobule entirely from the temporal lobe. The right pyriform lobule appears somewhat larger on the right than on the left.

The mesial surfaces present no remarkably anomalous cortical pattern. The corpus callosum is narrow in its horizontal portion as compared with the rostrum and splenium. There is no middle commissure.

The frontal sections show no pathological lesions. The cortex is everywhere of good width. There appears to be a rather smaller corona radiata than one usually finds. The basal gray matter is present in the usual amount.

The callosal angles of the lateral ventricles are rounded, but there is no definite enlargement of the ventricle cavity.

The cerebellum, pons and medulla are negative to gross examination.

d) Microscopic Examination.

The results of partial microscopic examination may be stated as follows:—

The most striking and general characteristic of the tissues is the generalized gliosis involving both an increase of cells and increase of fibrils. This gliosis affects the spinal cord as well as encephalic tissues. There is a suggestion of narrowing of the cortex cerebri throughout and a crowding together of the laminae. The blood vessels are everywhere prominent; this appearance is partly due to thickening but largely due to the frequency of perivascular gliosis.

One of the most important findings in the case is that of rod cells such as were found in case VI (although in case VI there are a few foci of perivascular infiltrations). The variations in the different areas examined are quantitative rather than qualitative. The rod cells are found most frequently in the precentral, post central, calcarine and temporal areas.

One area, the right transverse temporal, shows a canalized thrombus in a small vessel, with a vacuole or approach to a small glia-lined cyst nearby. There is a small acute hemorrhage under the pia mater of the right angular gyrus. The right superior frontal region appears to show a larger degree of cell atrophy (with numerous shadow cells) than is found elsewhere.

e) Anatomical and Histological Summary.

This brain of an imbecile weighed 1270 grams, is fairly complex in construction, of fair size, with slight asymmetry and a narrow corpus callosum as to its horizontal part. There is apparently no definite enlargement of the ventricular cavity. Microscopically there is a generalized gliosis which involves not only the encephalic tissues but the spinal cord. The most important finding in the case is that of rod cells, as in Case VI, but the perivascular infiltrations of Case VI are not present in Case VII. The rod cells are more widely distributed in the present case.

A canalized thrombus in one region may be regarded as another sign of acquired lesion; but as to the date of this lesion nothing can be said. Note is made below of the fact that the mental age of this patient, set in a general way at 5 years, was regarded in some respects as over-estimated since in a number of directions the patient appeared to verge upon idiocy.

Synopsis of Findings of Case VIII.

a) Clinical.

This case will probably be reported *in extenso* elsewhere in collaboration with Dr. G. B. Magrath, Medical Examiner of Suffolk County, who performed the autopsy in pursuance of official duty. We have acted as his deputies in executing our brain studies.

The case belongs in Dr. Magrath's series of "judicial homicides" having been electrocuted for murder. A number of more or less competent persons regarded the subject as "defective." Further details are reserved for the present. The brain is presented as a foil to the others of the series. If "feeble-mindedness" is a term roughly equivalent to inability of self-support, then this subject should perhaps not be regarded as feeble-minded. If "defect" may be used to include lack of "normal inhibition," then probably this case might classify as defective.

The subject was physically well developed, had been a "nervous" and "bad" boy, could read and write, had marked practical ability in certain ways, earned a sort of living, was criminalistic, had an

ungovernable temper and was easily overcome by alcohol. There is no means of knowing what his mental "grade" would have been; we have placed it at 12 plus.

b) Autopsy.

Gross findings reserved.

c) Special Anatomical Description of Brain.

There is slight asymmetry of the occipital lobes; the right is thin and points away from the median line, while the left does not.

The pia is thickened and white over the vertex, and the vessels are considerably injected; particularly the larger ones.

The convolutional pattern is noticeable in that the direction of the gyri is a transverse rather than an antero-posterior one. (This has been noted as a developmental anomaly in mental defectives.) The gyri are well rounded and of fair width, but their summits are not approximated. The markings are of medium complexity in the anterior region, but less so in the part adjacent to the central lobule.

In the central region the precentral gyrus is unusually wide in its upper third; the postcentral is very narrow in its upper third, but becomes of average width below. The upper extremity of the fissure of Rolando extends barely to the border of the superior longitudinal fissure and approaches it at an acute angle. The lower extremity does not cut the operculum.

The parietal lobes are well developed with distinct markings. On the right the interparietal sulcus is typical; the postcentral portion is continuous and is intercepted at its middle point by the horizontal limb. On the left the ascending postcentral is separated by a narrow annectant from the descending and horizontal branches, which are continuous. The convolutions of the inferior parietal lobule are broader and less complex than those of the superior parietal. This lobule is marked both by longitudinal and transverse fissures. The entire lobe is characterized by the lack of approximation of the walls of the interparietal fissure and of the convolutions of the superior lobule.

The occipital lobe is not remarkable; the convolutions are of good width, fairly well rounded, their walls well approximated, and of complex arrangement.

On the orbital surface the convolutional pattern is not markedly different from that ordinarily seen.

The pyriform lobules are noticeably asymmetrical; the right is considerably wider than the left, and this is true of the entire hippocampal lobule. The rhinal fissure (Turner) is well marked. The convolutions of the extreme tip of the right occipital lobe are narrow and irregularly arranged. The sulcal pattern over the entire base of the brain is unusually symmetrical.

The main differences of configuration on the mesial surface are the presence on the left of two sulci parallel with the callosum, while on the right there is but one. On the left, the parieto-occipital fissure is wide open, disclosing an otherwise hidden convolution which dips down from the superior surface of the superior parietal lobule and turning back upon itself, joins posteriorly with the superior occipital gyrus. The sulcal complex on the right precuneus is triradiate, while that on the left is made up of four branches. The former has one fissure extending upward toward the superior margin, and two downward and outward; on the left two point upward and outward, and two downward and outward.

The callosum is of good extent and thickness except in the posterior third of the horizontal portion where there is moderate narrowing. The middle commissure is present.

The frontal sections illustrate well the lack of complete longitudinal sulci in the frontal lobes; these can be easily identified only in the most anterior portion.

There is nothing remarkable in the appearance of the cortex, nor of the basal nuclei.

The ventricles are not dilated.

d) Microscopic Examination.

The results of a partial microscopic examination may be abstracted as follows: —

Gliosis is noted in numerous areas but was rarely of marked degree and often showed a tendency to focalization. Subpial gliosis is noted in the paracentral, postcentral (more marked left), temporal pyriform, cornu ammonis, left prefrontal, right insula, and Broca areas. This subpial gliosis is, as a rule, more marked at the bottoms of the sulci or along their sides than at the tops of the gyri. It is not often of marked degree.

Perivascular gliosis is especially noted in the right precentral, right middle temporal, superior frontal, middle frontal prefrontal and Broca areas.

Satellitosis is especially noted in the paracentral, right postcentral, left cornu ammonis, superior frontal, middle frontal, prefrontal and insula regions, and to a lesser extent in several other regions. Gliosis of the white matter is especially noted in the right middle temporal, middle frontal, prefrontal, insula and Broca areas, as well as in areas noted above, showing perivascular gliosis in the white matter.

Dislocated ganglion cells are noted especially in the white matter of the right precentral area and appear in general to be rare in this case.

The only instance of exudate consists in infiltration of the space about the small blood vessels in the left prefrontal region, where cells are found highly suggestive of plasma cells. Evidence of recent cell destruction, completed or in process, are few but distinct. The notes show cells with poorly staining nuclei and surrounded at their bases by satellite cells in both paracentral regions. Satellitosis was also found in the postcentral region in considerable degree.

In the right transverse temporal gyrus, cells are occasionally found of the small pyramidal type, having a clear ring outside the nucleus, suggesting that the chromatic substance had undergone a solvent process in the cell interior. Shadow cells are found in the pyriform lobules and are here associated with cells showing the clear perinuclear rings just mentioned as found in the transverse temporal region. Other areas show occasional cell changes of the same general nature.

The total brain sections in this case show deep sulci, possibly more so on the left side; the cortex roughly averages 3 mm. in depth at the summits of the gyri and is thinner elsewhere. The white matter appears to preserve a fair proportion to the cortex. There seems to be notably less white matter on the left side of the brain. The larger vessels in the white matter are surrounded by large pigment-laden cells.

Especially interesting was a slight degree of heterotopia of the gray matter consisting in four small areas below the cortex on the superior surface of the temporal lobe. The blood vessels of the temporal lobe show dilatation of their perivascular spaces with a few large pigmented cells. The ventricles are not dilated; the corpus callosum is of proper thickness, approximately 8 mm.

It does not appear that there is any evidence of thinning out of the nerve fibers. The suggestion that the left hemisphere has comparatively less white matter than the right is based upon observations both in the anterior and posterior part of the brain.

e) Anatomical and Histological Summary.

This brain (1340 grams) in a physically healthy, executed subject, is found to show a number of minor asymmetries, such as the transverse direction of convolutional pattern in many regions. The summits of the gyri are not always approximated. The corpus callosum is of proper size except for a moderate narrowing in the posterior third of the horizontal portion, in which latter connection may be mentioned that the parietal lobules are especially characterized by the lack of approximation of the walls of the gyri.

Microscopically there is a certain tendency to slight gliosis of a focalized nature. This gliosis is more, as a rule, at the bottoms of the sulci where there is normally more fiber-producing tissue. Both the fibrillar gliosis and satellitosis are fairly widespread in cortex and white matter and there is a certain amount of perivascular gliosis. The argument for fundamental hypoplastic changes may perhaps best be based upon dislocated ganglion cells in the white matter of the right precentral area, but the rarity of such cells is conspicuous and it would not seem well to make a diagnosis of hypoplasia or heterotopia upon this single finding. Again, the single focus of perivascular infiltration by cells resembling plasma cells in the left prefrontal region is perhaps but slight evidence on which to ground the hypothesis of brain changes of an important nature in this executed criminal. A vast deal of comparative work in "normal" cases must yet be done before a decision can be rendered on such a point.

That the case had inborn peculiarities may be argued from the stigma of heterotopia in the temporal lobe and perhaps somewhat upon the deep sulci, possibly deeper on the left side, which the total brain section demonstrated. The suggestion that there is somewhat less white matter on the left side of the brain than on the right may also be entertained as indicative of inborn peculiarity. There is in the case apparently no evidence of thinning out of the nerve fibers.

An analysis of this case in comparison with others in a series of executed homicides will be profitable.

Synopsis of Findings of Case IX.

a) Clinical.

1. Physical Examination.— Patient was born August 3, 1875; admitted May 17, 1883; died August 30, 1914. The patient at autopsy showed an enlarged thyroid and cystic kidneys, but had no other anomalies. The stomach was dilated. He is described as having been a strong and healthy subject.

Voice hoarse, words pronounced in a staccato manner. Patient a little deaf; at all events, later in life.

2. Family History.— Father and mother are said to have been strong and healthy; the father 30, and the mother 32 years old at the time of the birth of this child. There had been four children before the birth of the patient, and one thereafter. One of the children had died of "summer complaint." It is stated that there are no evidences of deformity or mental deficiency in the other children. The mother died in childbirth, at 37 years. The family was American.

3. Personal Developmental History.— Patient began to walk at 2 years, and to say a few words at 5 years. His mental deficiency was noticed at 3 years of age, when it appeared that he was not trying to talk. At 8 years, when patient was admitted to the school at South Boston, he could not talk plainly and had untidy habits. He had not learned to read or write.

4 and 5. School Progress and Examinations.— Patient upon admission was placed in the training classes, and learned a good deal. He learned to do simple outdoor work on the farm, such as grub-hoeing, picking up stones, and the like. In his 25th year, he was transferred to the Colony, where he developed markedly and was regarded as fairly intelligent and industrious. His strength and abundance of health permitted him to help the blacksmith; he could measure and saw off wood, and use a plane and sandpaper. He would keep the blacksmith's tools lined up for him, and assist in shoeing oxen.

6. Practical Knowledge.— His practical knowledge is indicated by the remarks under *School Progress* (see above). Although he could use the plane, saw, and chisel well, his sense of measurement was so deficient that, for instance, he could not tell the difference between 5 and 9 inches. However, if given a piece of board 4 inches wide, patient could go and get another of the same width. If the car-

penter marked with pencil a line to which patient was to plane on a piece of board, he could plane to that mark. Practically speaking, he seemed to be better than his Binet age would indicate.

7. **Economic Efficiency.**— See above.

8. **Social History and Reactions.**— Patient was much beloved by the caretakers. He was kind-hearted and anxious to please, and after his fashion had a very keen sense of humor, apparently understanding much more than he was able to express; used nouns, active verbs, and a few descriptive words, but never learning to put sentences together.

9. **Moral Reactions.**— Patient belonged in the amiable and " altruistic " group.

10. **Psychological Tests.**— Binet tests performed in 1914 show the patient to be of a mental age of 7.

Waverley School History.— The advance of this patient under supervision and the conditions of the school, and later of the colony, was considerable, as above indicated. As the patient grew older, he was given more difficult work, which he was able to perform with fair satisfaction; this progress was of a degree rather unusual in the feeble-minded. Patient was fond of music and of humming melodies, although he did not pronounce the words.

The patient was killed by being run down by an automobile while being taken off the grounds with a group of boys on an outing. He had been in general regarded as able to take care of himself and keep out of the way of traffic, although the conditions of state roads may have been more complex than ordinary for him. There was a certain error of judgment on the part of the automobile driver.

b) Autopsy.

Body of a well built and nourished white male 5 ft., 10 in. in length (177.8 cm.). *Skin* rosy grey but shows marked number of recent abrasions as follow:

Right parietal boss is prominent and exhibits a superficial cut 5 cm. in length by 0.5 cm. in width. Hair shaved on this side. *Right mid scapular* line shows abrasions 3×0.5 cm. *Right elbow* 3 small ones 3×2 cm. in extent. *Right lumbar region* just above crest of ilium 5.0 cm. $\times$ 1 cm. *Right popliteal* space 5×1 cm. *Right knee* inner aspect 3×0.8 cm. *Right mid shin* anterior aspect 3×2 cm. *Left, below crest of ilium* (gleutial side) an abrasion 12 cm. in length $\times$ 2 cm. wide. *Left thigh* lower third outer aspect is another 3×1 cm. *Left knee* inner aspect 2×2 cm. *Bruises, right knee, right shin, right ankle* (inner and outer aspects), *left ankle* slight bruising 7×7 cm.

Rigor mortis present, in legs — not in arms. No palpable lymph nodes. *Pupils* 0.5 cm. equal. Slight amount regurgitated material left face and neck.

Ventral Section.— Fat over abdomen measures $3\frac{1}{2}$ cm. Over thorax $\frac{1}{2}$ cm. Muscles red. Peritoneum is bluish red in lower anterior portion and there is blood between the fascia of the rectii muscles and the peritoneum as high as 10 cm. above the symphysis. There is *free blood* in the peritoneal cavity, estimated quantity 25–40 cc. The *intestines* are dilated, the *liver* is above costal margin and lightly stained with blood. *Stomach* dilated and 10 cm. in length. *Spleen* free. *Mesenteric lymph nodes* not palpable. *Hemorrhages* exist in the layers of the mesentery. *Diaphragm* arches to the 4th rib in right to 4th on left.

Thorax.— Muscles removed from anterior thoracic wall shows much hemorrhage into the muscles between the *left clavicle* and sternum between 1st and 2nd rib. On the right between clavicle and first and between 1st and 2nd ribs, there is a separation of the clavicle and the sternum *on the left* by hemorrhagic and edematous muscle and the first rib is broken approximately 1 cm. from the junction of it to sternum. *On the right* the upper end of the chest wall sinks in a little more than the left and a fracture is present on right first rib 8 cm. from mid sternal line and the 2nd is also fractured somewhat latterly to the first. Anterior portion right chest presents subperiosteal fractures of the 7th, 8th, 9th and 10th ribs with marked hemorrhage into parietal pleura. None on the left.

Upon removal of the lungs, there is also seen marked hemorrhage in posterior surface of right pleura and underneath it the 3rd, 4th, 5th, 6th, 7th, 8th ribs are fractured about 1–3 cm. from vertebrae and 10 cm. from vertebrae the 10th and 11th ribs are also. Marked hemorrhage into posterior mediastinal tissue, on either side, also retroperitoneally in abdomen. *Heart* weight 12½ oz. (354 grams). Epicardial fat scant, muscle somewhat pale but firm. Valves negative. Endocardium smooth.

Measurements: T.V. 5¾ in. (14 cm.) P.V. 3¼ in. (8.25 cm.) L.V. ½ in. (1.2 cm.).
M.V. 4¾ in. (12.0 cm.) A.V. 3½ in. (8.8 cm.) R.V. ⅛ in. (0.3 cm.).

Lungs.— Right 22½ oz. (638 grams). Left 20½ oz. (567 grams.). Nothing of note except old adhesions left apex and recent congestion of both lungs.

Organs of the Neck.— Thyroid markedly enlarged and protuberant; weighs 3½ oz. (99 gms.). Normal on section except right lobe which is very much congested. *Tongue, larynx, trachea, esophagus* negative.

Abdomen.— *Spleen* 6½ oz. (184 gms.). Nothing of note. Capsule not thick, pulp fairly soft, trabeculae prominent. *Adrenals* small; otherwise negative.

Kidneys 9½ oz. (269 gms.). One kidney fairly normal; the other, the left, is studded with smooth, firm glistening bodies 0.2 cm. to 0.3 cm. in diameters. Capsule peels with difficulty. Cortex reduced and replaced by these cysts which appear colloidal; the cortex is also injected. Pelves negative.

Liver 58½ oz. (1610 gms.). Nothing of note. No gall stones.

Pancreas. Very white instead of yellow and a curious softness unlike the usual gland. No hemorrhages.

Gastro-Intestinal Tract.— Negative throughout. Remains of hastily eaten vegetables in stomach. Well distended, few rugae.

Genito-Urinary Tract.— Bladder external wall very hemorrhagic; inner wall clear. Clear fluid in bladder. *Prostate* not examined. *Testes* thread well.

Retroperitoneal Tissues.— Aorta and branches smooth and elastic. No lymph nodes seen. Marked hemorrhages into the retroperitoneal tissues.

Head.— Hair brown, cropped on right. No marks on inner side of scalp. Calvarium thick; frontal ¼ in. (0.6 cm.); temporal ⅛ in. (0.3 cm.); occipital ⅜ in. (0.9 cm.). Not much diplöe. Dura thickened but not adherent. Pia thin and delicate. Convolutions simple and wide, in every location. General feeling of "normalness" to fingers, slightly putty-like at base. No atrophy nor gliosis.

At the base, a slight amount of meningitis bends the optics, the circle of Willis and the 3rd nerve together. Tips of olfactory bulbs adherent to skull. Optic nerves slightly edematous but smaller than normal. Ganglions and pituitary negative. Ears and discs not examined.

Brain wt. 54 oz. (1622 grams.). Cord not removed.

Anatomical Diagnosis.

Well nourished.
Abrasions, head, trunk, extremities.
Bruises, extremities.
Subperitoneal hemorrhages.
Free blood in peritoneal cavity.
Mesenteric hemorrhages.
Intercostal hemorrhage.
Fractures ribs, right anterior 2nd, 7th, 8th, 9th, 10th.
Fractures ribs, right posterior 3rd, 4th, 5th, 6th, 7th, 8th, 10th, and 11th.
Fractures ribs, left, 1st rib.
Slight adhesive pleuritis.
Pulmonary congestion.
Enlarged thyroid.
Cystic kidneys.
Hemorrhagic cystitis (bladder wall).
Retroperitoneal hemorrhages.
Normal brain.
Slight edema optic nerves.
Brain weight 1622 gms.
(Tigges' formula 1424.)

c) Special Anatomical Description of Brain.

The brain of this case is large and suits the dolichocephalic skull. The orbital frontal angle made between the basal and lateral aspects of the frontal lobe is unusually prominent throughout. The occipital lobes exhibit a slight degree of asymmetry; the inferior parietal lobules are slightly more prominent than the surrounding tissues.

The intermediate precentral area has the "coronal" type of construction. The gyri are in general of good width and of fairly simple pattern. The summits of the gyri do not, as a rule, well approximate; in many places the summits do not lie in the same plane; this gives the brain surface a motley, irregular configuration, somewhat suggestive of foothills.

The corpus callosum is of a good depth except in the posterior third where it is comparatively narrow. There appears to be no middle commissure.

The pia mater is slightly thickened and hazy throughout and the arachnoidal villi are moderately well developed along the vertex of the superior longitudinal fissure. There are small pinpoint white nodules in the pia mater, especially over the sulci, chiefly in the region of the superior parietal lobule.

d) Microscopic Examination.

An abstract of the most important findings yet made is as follows: —

Subpial gliosis is nowhere in evidence. Gliosis of the white matter is found in a number of areas, precentral, postcentral, temporal, occipital, frontal, but is nowhere marked. There is no perivascular gliosis except for a slight amount in the section over the right prefrontal region. Satellitosis is nowhere noted.

The fiber stains show no notable variation from the normal (as judged by drawings in Campbell's "Localization of Cerebral Function"), except that a section from the right superior temporal gyrus shows some diffuse thinning of radiary fibers; but even this appearance may possibly be regarded as artificial. We have not regarded the presence of knoblike enlargements along the course of the fibers as of pathological significance.

As might be expected from the nerve fiber and glia appearances, the nerve cell pictures are not far from normal upon qualitative examination. There are, however, a number of stratigraphical appearances consistent with the hypothesis of arrest of development. Thus the supragranular layers of the precentral, postcentral and frontal regions are not definitely laminated.

The evidences of cell loss or numerical hypoplasia in the supragranular layers is, as a rule, confined to the lower portions of these layers. The granular layers are, as a rule, distinct, where they are normally distinct and in general of a normal appearance, unless we regard the cells as slightly thinned out in some places (right upper postcentral, right superior parietal).

The infragranular layers show apparent scarcity of cells in a number of regions, for example, precentral, postcentral, occipital, superior parietal.

The above description suggests a certain irregularity in the distribution of the hypoplasia. The area which more than any other shows architectural disturbance appears to be illustrated by a section from the right superior frontal region. The cortex here shows a narrow plexiform layer but underneath a complete absence of distinct lamination. The granular layer, for example, is nowhere distinct. The scarcity of cells seems to be a definite one and of a convincing degree. The cells that persist show a variety of staining reaction — many of the cells have a pale and finely granular protoplasm. On the other hand a good many cells contain perfectly staining Nissl granulations; there is a moderate degree of phagocytosis in the perivascular spaces in this area and, as above noted, a slight cellular gliosis in the white matter.

The sections stained for the demonstration of neuroglia fibrils fail to show any convincing increase thereof. The Weigert myelin sheath stains are negative as to nerve fiber change. The prefrontal cortex on the right side shows an even more marked scarcity of cells.

A type of problem is brought up, for example, by a section from the right upper postcentral region. Here there is a number of giant pyramidal cells suggesting that there might have been an error in the labelling of the section and that it had been mistaken for a section of precentral cortex. On the other hand, the supragranular layer in the cortex here sectioned is much more like the postcentral cortex and there seems to be no reason for supposing that in this case there was a mislabelling of sections.

A section from the right intermediate postcentral gyrus shows an unusual tendency to the grouping or bunching of nerve cells in compact nests containing 2–3–4 cells; sometimes the nerve cells are found overlying each other slightly.

In a section from the right superior occipital area, a number of dislocated ganglion cells are found a good way into the white matter. One of these dislocated cells was found with two nuclei. On the whole, however, in this case there are not many instances of dislocated ganglion cells in the white matter.

e) Anatomical and Histological Summary.

The brain of this imbecile of 39 years weighed 1622 grams, as is perhaps consistent with his belonging to what is sometimes termed, for practical purposes, the able-bodied or colonial type of feeble-minded. The corpus callosum is of good depth except for a narrow place in the posterior third. Microscopically we failed to secure evidence of gliosis in the subpial region nor marked evidence of gliosis in any locus. In particular, there was no evidence of satellitosis. Accordingly we may regard this case as without evidence of active phenomena, whether inflammatory, sclerotic, neuronophagic. There was one region in which there was a moderate degree of phagocytosis in the perivascular spaces. This region, the right superior frontal, was interestingly enough the region in which occurred the most marked architectural disturbance with a complete absence of distinct lamination.

This brain, accordingly, shows one of the purest examples yet seen of uncomplicated irregular arrest of development with stratigraphical, architectural alterations (right superior frontal, right upper postcentral, dislocated ganglion cells, right superior occipital) without complications of acquired disease.

Synopsis of Findings of Case X.

a) Clinical.

1. Physical Examination.— Patient was born Oct. 3, 1876; admitted Feb. 17, 1887; died of pellagra, Nov. 17, 1914. Patient was slenderly built, and well nourished up to two years before his death, when pellagra set in. From the autopsy findings, some points concerning the physique of the patient may be taken. The nose was saddleshaped and the head narrow, dolichocephalic, eyes small, ears irregular with adherent lobules, prominent abdomen. The patient was never very strong and had a poor circulation so that he could be kept out of doors only in the warm weather.

2. Family History.— The father was a native American, 25 years of age at the birth of the child. The mother was born in Canada, and was 20 years of age at the birth of the child. She had had one child before the birth of the patient, and has had two since without evidence of physical deformity or mental deficiency. There is no history of mental disorder in the family. There was nothing unusual about the pregnancy or delivery.

3. Personal Developmental History.— The patient began to walk at two years; was not able to

talk, and is described as having been of a passionate temper. Late in talking; could say very few words at time of admission.

4 and **5. School Progress** and **Examinations.**— There was improvement physically when the patient was placed in the outdoor classes.

6 and **7. Practical Knowledge** and **Efficiency.**— Patient could carry stones, use a grubhoe, carry bundles, and rub floors.

8. Social History and Reactions.— Patient had a quick temper and would attack people who got in his way. On account of his tendency to cruelty to weaker subjects, he was kept with the older boys. He could say a few words, could not talk in sentences, but used profane and obscene phrases.

9. Moral Reactions.— Patient was more or less irritable, violent, inclined to be noisy, and as above stated would attack persons. Masturbation.

10. Psychological Tests.— Binet test made in 1914 showed the patient to be 2.4 years of mental age.

Waverley School History.— The patient grew more and more troublesome as he grew older, becoming noisy and more untidy. In his thirty-seventh year, the patient began to lose weight and became emaciated, and developed a peculiar skin eruption on the back of the neck and extensor surfaces of the hands. The eruption was symmetrical and was regarded as pellagra. This eruption healed with stimulating ointments, and the patient grew physically somewhat better. Later the eruption returned and, despite outdoors treatment, a decubitus developed, finally covering a portion as large as a dinner plate, with great destruction of tissue and offensive odor.

b) Autopsy.

Body of a slenderly built and poorly developed white male, 144 cm. in length. *Skin* is yellowish grey except over the face where it is diffusely pigmented (freckles) and over the exposed portions of the head where the hair sparsely grows (frontotemporal region): here it is a deep brown color with crackled lines alternating with patches of white. This condition is especially marked in the back of the neck extending as far backward as the 7th cervical vertebra where it is abruptly replaced by normal appearing skin. The *hands* are brown, especially over the knuckles where the skin is scaling, so much that it may be lifted from the pale true skin. This pigment is apparent on the hands up to the wrists and extending in a gauntlet shape 4 cm. above the wrist where it also fades from this diffuse and dense color into isolated pigmentation (freckles) that gradually become less until the axillary region is reached. There are some scattered freckles over the chest and abdomen and upper thighs.

Over the mid-shin region of both legs there are brawny brown areas measuring 8×4 cm. and 12×6 cm. There is a bruise measuring 3×2 cm. over the anterior surface of the right mid-thigh; another 4 cm. above left patella.

There are *gangrenous areas* on the skin over the posterior portion of the right shoulder, measuring 4×3 cm., over the right trochanter major measuring 12×10 cm. This is markedly sloughing and extends deeply into the muscular substance. Probing this muscular substance, a soft, mushy, non-resisting tissue appears in the place of the normal firm resisting muscular tissue.

A similar area over the left trochanter major measures 8×6 cm. over the left shoulder, another measures 4×5. Also in the inner surface of each knee similar areas vary in size from 3×4 cm. — 1×1 cm. and 0.8×1 cm. in diameter.

A few scattered hairs over upper sternal region. Pubic hair more or less triangular in shape, grows in a straight line to the ensiform; hair also grows on inner thighs, also legs and forearms. There is scanty evidence of hair over face.

Nose slightly saddle shape with broad bridge and small alae.

The *pupils* are dilated and unequal; the right measures 0.7 cm., the left 0.6 cm. The lips show

sordes. The *teeth* are poor and there is a bloody fluid between them. (Some report of sore mouth previous to death).

Ventral section.— Fat over abdomen 1.0 cm., over thorax, 0.5 cm. Muscles pinkish. Peritoneum is grey.

Liver.— 6 cm. *Stomach* 8 cm. *Transverse colon* 15 cm. below the ensiform.

The *omentum* is very rich in fat and covers intestines completely. *Intestines* are injected and slippery to the touch. The appendix measures approximately 4 cm. and is large at its distal end. The *bladder* is not distended. There is a little free fluid in the abdominal cavity. The *mesenteric lymph nodes* not enlarged. Spleen exceedingly large. *Diaphragm* arches to the third rib on the right and to the 5th on the left.

Thorax.— Lungs adherent to the chest wall in the mid-anterior portion. There is no free fluid in the *pleuric cavities.* Pericardial sac contains slight traces of fluid.

Heart.— Assumes a circular shape on being removed. It is very flabby and it would be difficult to tell which were the left side on inspection. The descending branch of the left coronary is smooth and delicate, as is the right coronary. *Myocardium* is pale and flabby and not friable. Valves are negative except the aortic which shows a sessile red adherent body clinging to the middle of the posterior cusp measuring approximately 0.8 × 0.6 cm. No other vegetations.

Approximate measurements: TV 8.0 cm. PV 5.0 cm. LV 0.9 cm.
MV 9.0 cm. AV 8.0 cm. RV 0.3 cm.

The intima of the *aorta* is very red and firm.

Lungs.— No weights taken. Right lung has but two lobes. The upper is normal; the lower is injected on lateral surface and on section there is reddening of the lung tissue superficially. *Bronchi* are covered by reddish thin fluid. Left lung is markedly congested in the posterior portion. Pleura has been torn on removal of lung but there is no raised area around the bronchi at that point. There is a small area not more than 3 cm. in diameter where the bronchi have induration about them in the central portion of the lower lobe. *Bronchi* reddened throughout.

Organs of the Neck.— Not removed.

Abdomen.— *Spleen:* Markedly large; measures approximately 14 × 10 × 4 cm. *Capsule* not thickened but dark areas (?). Hemorrhages show through the capsule. On section the pulp is very soft, scrapes heavily and the malpighian bodies faintly descernible. The *pulp* swells above the cortex on section and there are greyish pink wedge shaped areas with their bases toward the capsule that show red external borders. *Trabeculae* indistinct.

Adrenals.— Small. The cortices are both pale yellow edematous and fade into a deeper brown at irregular intervals. The central portion is brown and there is no softening.

Kidneys.— Fairly well supplied with fat. Capsule strips easily but is opaque. The cortex measures 0.6 cm., is brilliantly and uniformly injected and red points dot the intervascular injections. At one point there is a bright yellow-grey wedge shaped body occupying the cortex for a space of 1.5 × 0.6 cm. The *pyramids* are poorly differentiated, look yellow in their centers. *Pelves* markedly congested. The other kidney not so injected but swells over capsule on section and on stripping the capsule the kidney surface is pulled away at two points. No *cysts* seen.

Liver.— Measures approximately 20 × 18 cm. The surface is mottled yellow and red. Cut surface swells slightly over the capsule. Color of the liver on section is not remarkable; shows lobules well marked but no congestion. The *gall bladder* very small; contains a few cc. of turbid yellow fluid.

Pancreas.— Not examined.

Gastro-Intestinal Tract.— Stomach dilated. Swells somewhat; edematous; no rugae. Mucous wall drips grey fluid and the wall has a granular and somewhat injected appearance. The same is true of the lower tract but no ulcers of hemorrhagic state of the intestines seen, with the exception of focal areas of injection in the upper third of the descending colon. The content of the entire intestinal tract and particularly the colon is fluid brown yellow.

Genito-Urinary Tract.— *Bladder* negative. *Prostate* not enlarged. *Testes* not examined.

Retro-Peritoneal Tissues.— The lymph nodes are not present. There are (?) hemo-lymph nodes along the aorta. The sympathetic ganglia small. The *aorta* is small in calibre and thin walled. The peripheral nerves negative.

Head.— The cranium is narrow, measures 52 cm. in circumference and the hair grows scantily over the entire scalp. The scalp is adherent and inelastic. *Calvarium* is dense and measures, frontal 0.4 cm., temporal, 0.2 cm., 0.4 cm. and occipital, 0.6 cm. Grooving for the middle meningeal arteries very narrow and shallow on the right. The *dura* is not adherent and in the frontal region one sees the convolutions through it. There is some thickening of the dura in the middle meningeal distribution. The longitudinal sinus free. The dura seems dense and fills the cranium cavity except in the frontal portion where there is a space between the frontal portion and the inner table sufficient to insert three fingers. The pia mater is somewhat injected over the vertex.

The *brain* is exceedingly compact and firm.

At the base of the brain a striking appearance is presented by the depression of the orbital portion of the frontal lobes in their central portions and the marked foreshortening or (?) absence of the prefrontal regions. The olfactory bulbs somewhat softened. The *optic nerves* slightly thinned but show no atrophy. The pia mater over the cerebellum is markedly thickened and opaque. The floor of the *4th ventricle* is clear. *Pons* and *medulla* are firm. There is marked pressure pointing over each lobus pyriformis. The *3rd ventricle* contains a quantity of clear fluid (specimen taken for gold reaction).

The *superior surface* of the brain is uniformly firmer than normal, there being no points of softening or change in consistency with the exception of the posterior portion of the left angular gyrus. The convolutions of the entire surface have a tendency to be less plump on the crowns than is normal; this is seen particularly on the right side.

The *occipital lobes* somewhat foreshortened but are flush with the cerebellum. The first temporal on the right is slightly wider than its fellow and there is a difference in the winding of the second convolution.

The *Gasserian ganglia*, the *pituitary*, the *optic discs*, *middle ears*, and *cord* negative on section.

The brain weight is 1450 grams.

Anatomical Diagnosis.

Poorly developed.
Pellagra.
Bruises, extremities.
Decubitus (Shoulder and trochanter major, knees.)
Saddle shaped nose.
Unequal pupils.
Sordes on lips.
Teeth poor.
Induration appendix.
Chronic fibrous pleuritis.
Acute vegetative endocarditis (aortic valve).
Pulmonary congestion; beginning bronchial pneumonia.
Acute bronchitis.
Acute splenitis.
Infarct spleen.
(?) Post mortem change adrenals.
Infarct of Kidney.
Acute parenchymatous nephritis.
Acute hepatitis.
Chronic gastritis.
Head narrow.
Scalp adherent.
Calvarium dense.
" thin.
Focal thickening of dura.
Injection pia.
Thickening of pia cerebellum.
Evidences of brain swelling.
General cerebral gliosis.
Superficial atrophy convolutions (flattening of crowns).
Inequalities first temporal convolutions.
Brain weight 1450 gms.
(Tigges' formula 1152 gms.)
Cord not remarkable.

c) Special Anatomical Description of Brain.

The brain in general suits the dolichocephalic skull. There is a slight occipital asymmetry such that the right lobe is shorter than the left, deviates somewhat more from the median line and has a groove upon the posterior extremity, whereas the left occipital lobe deviates slightly to the right and even somewhat overreaches the median sagittal plane (the posterior extremity of the left occipital lobe, however, deviates again leftwards).

The gyri of this brain are in general rather narrow, closely approximated except at the borders of the summits. The corpus callosum is of good width except for a somewhat narrow middle third. There is no evidence of the middle commissure. The cerebellum projects farther backward on the right than on the left (compare contralateral asymmetry of occipital lobes). The cerebellum suggests in general a reduction in size and the inferior surface of the cerebellum shows a considerable thickening of the pia mater, especially over the incisure. The pia mater of the brain in general is slightly thickened and hazy.

d) Microscopic Examination.

An abstract of important findings is as follows: —

Subpial gliosis is found in a number of areas, for example, focally in the precentral and postcentral angular gyrus; but in other areas the plexiform layer seems to be normal. The white matter is not, as a rule, affected by gliosis, although the angular gyrus of superior parietel area and frontal regions show a general increase.

Satellitosis is found in a number of areas (precentral, occipital, temporal angular, superior parietal, prefrontal.

The Weigert myelin sheath stains show a certain indistinctness in the supraradiary layers, precentral, postcentral, temporal, angular, superior frontal (here patchy). A good deal of this fiber change might be within the limit of artefact.

The nerve cells show numerical hypoplasia in a number of areas; the right upper precentral area, for example, shows very few cells in the supragranular region, aside from the outer small pyramids. This condition is less marked in the postcentral area where the distinction of supra and infragranular layers is more evident. The right superior temporal region shows marked cell scarcity and the arrangement of the cells is markedly irregular. The supragranular layer of the right angular gyrus is narrow and of a somewhat abnormal development. The infragranular layer here shows marked thinning out of cells. The right superior parietal area shows a more marked architectural disturbance in the infragranular region. The cells of the second supragranular layer are also much thinned.

The right superior frontal region shows marked lack of cells in the second and third layers. The prefrontal region, on the other hand, shows fairly well developed supra granular layers with a few foci here and there of thinning out. These foci affect all the layers. The infragranular layer also shows a tendency to patchy cell loss. This case being one of Pellagra shows a rather rich display of acute nerve cell changes, with excellent examples of the axonal reaction in the Betz cells. There was in one region (right, upper postcentral) a focus in which there were a few round cells in the perivascular spaces; it could not be made out that these were definitely lymphocytes and they may perhaps be regarded as neuroglia cells.

e) Anatomical and Histological Summary.

The brain of this case in an idiot or low imbecile of 2–4.5 years, Binet age, weighed 1450 grams, and may be regarded as fairly complex in construction. The grey matter, white matter and corpus callosum stand in fair proportion to one another, except that the gyri of the brain fail to approximate along the borders of their summits and that the middle third of the corpus callosum is narrow.

Subpial gliosis and satellitosis are in fairly frequent evidence, but there is little or no affection of the white matter by gliosis. The nerve cell pictures show, to qualitative judgment, frequent instances of cell scarcity affecting both the supra granular and infra granular layers.

The following is a brief characterization of each of the ten cases in the Waverley Research Series, which may be helpful for quick reference.

Case I. The brain of this microcephalic idiot, of a mental age estimated less than one year, has somewhat the suggestion of the brain of an ape. A good portion of the cerebellum is visible from the dorsal aspect of the nervous system. Whatever the cause of microcephaly, the fact that an elder sister of this patient was almost equally deficient and almost identically microcephalic, must be taken into account, as well as the fact that other children before and after the microcephalic pair seem to have been normal, or at all events not microcephalic. The mentality of this case was undoubtedly the lowest of our series.

Case II. Also microcephalic, this case presents a combination of microcephaly with a high degree of internal hydrocephalus. This hydrocephalus is one doubtless *ex vacuo*, being very possibly due to an early non-syphilitic (poliomyelitic?) infection at three months of age. The detailed description will show how well preserved was the vision of this case, functionally speaking, despite the remarkable cystic condition and microgyria of the posterior portion of the cerebrum. In point of fact, the visuo-sensory portion of the cortex appears, however, to have been preserved, and the tremendous lesion to be noted on the upper aspect of the parieto-occipital regions did not take effect upon the elementary visual functions of the cortex. The case is evidently one of focal brain lesion, and very probably belongs in what Tredgold would call the group of "secondary amentia." Of course it is possible that the microcephaly was in some sense an example of primary amentia and that the focal posteriorlying lesions with compensatory hydrocephalus were due to intercurrent disorder. It is possible, accordingly, that this case may be one of a combination of primary and secondary amentia.

Case III. The brain of this microcephalic imbecile was so small (610 grams) that any coarse arrangement of the brains of the present series (Cases I–X) must naturally show "Zip's" brain lower than his actual capacity would have warranted. It is stated that this patient knew how to read and write a little. Although unable to support himself he had lived most of his years outside of institutions, being a harmless, amiable vagrant. With some hesitation, he may perhaps be placed among the imbeciles. Microscopic study indicates a special thinning of cells in the frontal and parietal regions as well as a degree of gliosis in the outermost layer of the cortex and below the appendema of the ventricles. The corpus callosum was well preserved and of a good size in proportion to the

brain. Microscopically the case will form an excellent foil to Case I, a case of far less intelligence, but the microscopy is complicated by gliosis, whose age is difficult to determine. (In this connection, it must be remembered that the patient is said to have had an epileptic attack at one time.) Although the brain at first sight seems a good instance of a brain in miniature, and although the frontal and temporal regions are fairly uniform, the parietal and occipital lobes are quite asymmetric, especially in that the right occipital lobe is considerably shorter than the left; there is a suggestion of an *Affenspalte* on the right side.

Case IV. This case is the oldest of the series (62 years), being an old almshouse case, apparently of feeble-mindedness, of unknown grade but apparently far higher than that of any other member of the series (except V, with the question of dementia praecox, and VIII, the executed murderer). It is of course possible that this case is an old dementia praecox (compare hallucinations observed at Danvers Hospital). The corpus callosum was rather thinner than normal; the brain weighed 1340 grams at death. Throughout the brain, in different places, there were various degrees of gliosis and satellitosis. This was especially marked in the left and right prefrontal regions. The whole brain suggested a slight degree of atrophy (slight sulcal flaring). There was a slight asymmetry, particularly of the poles of the brain; the parietal region shows a tendency to microgyria, and the right pyriform lobule is larger and more prominent than the left. There is a marked dilatation of the lateral ventricles except the descending horns. The gross appearance of the brain must be admitted to be entirely consistent with the hypothesis of dementia praecox; yet the case is a good instance of the so-called old demented imbecile found in almshouses and is of value in this series for comparison with others.

Case V. Case V falls in a group with Cases IV and VIII as of higher intelligence than any of the others in the present series (Cases I–X). It is possible that the original intelligence of Case V was higher than that in Case VIII, and highly probable that it was higher than that in Case IV. The case is interesting as showing the outcome of a truant high school boy existence. It is probable that the patient was a moron, or at all events a subnormal subject and perhaps belongs in the delinquent group. The unilateral moderate hydrocephalus is not infrequent in dementia praecox. The left frontal and right occipital lobes show contralateral asymmetry, being narrower than their fellows. The right occipital atrophy or aplasia appears to centre in the second gyrus. The corpus callosum in this case is of a good size. The brain weighed 1335 grams.

Case VI. This case is that of an idiot of two years mental age, who seemed to combine the typical features of idiocy in such a way as to be a case *par excellence* for clinical demonstration. The brain, weighing 1130 grams, shows the smallest brain weight of our series outside the group of pronounced microcephalic cases. The brain is of very simple construc-

tion. The histological examination showed in this case, as in Case VII, the occurrence of the so-called "rod cells" in the cortex. These cells, characteristic of general paresis when associated with the exudative and destructive changes found therein, are not to be interpreted as necessarily indicating syphilis when they occur alone. Perhaps they indicate merely proliferating vascular changes or proliferations of unknown nature of mesenchymal tissue. There is, however, a suspicion of syphilis in the antecedents of this almshouse transfer case, and certain "tissue paper" scars found on the skin at autopsy may add to the suspicion that this may be a case of congenital syphilis of a non-exudative type. It is also possible that good fortune, or a still more minute microscopic examination than we have been able to perform, would reveal exudative changes at some point. Another feature of the greatest interest in Case VI is the virtual absence of one vocal cord as demonstrated at the autopsy. This fact may serve to illustrate the difficulties of proper interpretation in routine cases. In this case, for instance, the aphasia could not be taken to be necessarily of nervous origin.

Case VII. Like the brain of Case VI, the brain of Case VII showed rod cells. With respect to the possibilities of syphilis in the family, it is important to consider that of five children, three of the children were dead (two of marasmus), and that the mother was subject to fainting fits. A great variety of anomalies in the body is probably entirely consistent with the hypothesis of syphilis. There was a certain irregularity in the mental capacities of the case, which should also be regarded as thoroughly consistent with this hypothesis. Thus the case, classified as an imbecile with a mental age of five, seemed in a number of respects not to reach above the highest grade of idiocy, or a lower grade of imbecility than the mental age would superficially indicate. There was some sensory disorder in the case as well. Accordingly, both VI and VII are cases which bring up the question of congenital syphilis of a character not so destructive or progressive as cases of exudative syphilis (of the group, for example, of juvenile paresis) would be. To be sure, the rod cells indicate a certain activity and progressiveness on the part of the disease. Theoretically and academically, at any rate, these cells may indicate that conditions are not so entirely stationary in the nervous system as we are led theoretically to suppose should be the case in the brains of the feeble-minded.

Case VIII. This belongs with Cases IV and V, amongst those of highest intelligence in the present series (Cases I–X). The case was that of an executed murderer. The brain was viewed on anatomical grounds to be that of a defective before there was any clinical confirmation or knowledge of the fact. The gyri were noted to be of a generally transverse direction. There was a lack of complete longitudinal sulci in the frontal lobes. A blunting of the frontal lobes was possibly the most convincing suggestion of the probable

clinical deficiency on the part of the subject. The parietal region was relatively and absolutely well developed. There was an asymmetry of the pyriform lobules, to some extent of the entire hippocampal lobule. The corpus callosum was of good size though there was a question whether it might not be regarded as somewhat thinned out posteriorly. It seems safe to regard this case as either in the moron group or as at any rate to some degree subnormal.

Case IX. Case IX illustrates the "ablebodied" type of imbecile (mental age, 7). The weight of the brain in this case was even in excess of what it should have been by Tigges' formula; namely: 1622 grams, as against 1424 by Tigges' formula. (It is true that the violent death of this patient may have led to a certain congestion of the brain which artificially increased its weight.) The brain of Case IX, quantitatively adequate as it would seem, was a brain which must strike the anatomist as of exceedingly poor mould.

Case X. The brain weight in Case X was also high, being 1450 grams, and in point of fact 298 grams in excess if we should trust Tigges' formula. He is described as of a very excitable nature. The brain shows a very considerable degree of hydrocephalus. Attention may be called to some theoretical points concerning hydrocephalus in these cases in a special section devoted to this topic. Case X, like Case VII, was of the excitable group, and the brain of Case VII also showed hydrocephalus, which likewise does not seem to be explicable on the basis of a compensatory condition (*ex vacuo*, as illustrated by Case IV), or an anomaly of the dementia praecox group (as illustrated by Case V).

III.

NEUROPATHOLOGICAL CORRELATIONS WITH CLINICAL AND PSYCHOMETRIC FINDINGS IN FEEBLE-MINDEDNESS (WAVERLEY RESEARCH SERIES, CASES I–X).

E. E. Southard and Annie E. Taft.

III.

NEUROPATHOLOGICAL CORRELATIONS WITH CLINICAL AND PSYCHOMETRIC FINDINGS IN FEEBLE-MINDEDNESS (WAVERLEY RESEARCH SERIES, CASES I–X.)

E. E. Southard and Annie E. Taft.

The province of the present article is limited. We intend to make a provisional epicritical review of the problems presented by the first ten cases (I–X) of the Waverley Research Series of cases of feeble-mindedness. This term we use to include, not only feeble-mindedness proper (i. e., the so-called morons of recent American nomenclature), but also the subnormal persons above the grade of morons, which modern research is bringing into the field of feeble-mindedness, and also the imbeciles and idiots which lie below the grade of moron or of the feeble-minded proper. It is the plan of the present series of anatomical examinations, therefore, to work up successively a series of all types and grades of feeble-mindedness and subnormality without undue regard to their clinical classification or intelligence grading. Already, however, the data of our first ten cases have suggested certain lines of correlation which it seems worth while to set down here in the guise of provisional hypotheses.

Among all the problems sketched above (problems of the schools, the courts, the social agencies, the eugenics record offices, the biological laboratories, and the like), perhaps no problem is more acute than that of the significance and possible future of mental tests after the manner of Binet. We must leave to the psychologists the evaluation of the details of these tests and the construction and choice of new variants. We must leave to those versed in the statistics of mental measurement the decision how far the age level of the Binet tests and the percentage level of the Yerkes tests apply to actual conditions. We must concede forthwith that Binet left but a torso of what the future has in store in the shape of mental tests, and we may concede that these tests, for the most part, yield little information as to those emotional and volitional impulses, instincts, and sentiments which are so important in social life. On the whole, however, it is generally admitted that progress is being made to a more and more accurate measurement of mental capacities of certain sorts. This bit of progress is enough to brighten the path of the anatomist. The anatomist feels that he must follow far in the rear of the psychologist and physiologist in his analysis; particularly in his analysis of deviations and perversions which are of a qualitative nature or cannot readily be reduced to quantitative values. When, however, the anatomist learns

that psychometry is not merely an idle dream, but that distinct losses,— when, at any rate, these losses are of large degree,— are demonstrable and to a certain extent measurable, his hope is kindled that the brain itself may unexpectedly at least yield up a set of useful correlations.

What is the relation of mind to brain? Speculation halts shortly before the intricacies of this problem when it is taken as a problem of the relation of the full-blown, healthy mind with the entirely normal, richly active brain. Important light is thrown upon the topic, of course, by the anatomo-clinical method which yielded such rich data in the last half of the nineteenth century; for by this method definite losses of brain substance were often found to be associated with equally definite losses of mental power. The limitations of this method are numerous and need not detain us. The method has not been exhausted; but its future fruits depend upon elaborate tissue analyses which the ordinary laboratory and the ordinary scientific leisure available under our present institutional system do not permit. Almost equally rich results have accrued from work in comparative anatomy, latterly supplemented by behavioristic studies.

What we at present need is to supplement the methods of normal neurology and psychology, the methods of anatomo-clinical research, and the methods of comparative anatomy with a method which has alliances with each of these but seems to us to contain certain elements of novelty. It would be strange if the field of anatomy in feebleminded-ness were not full of novelty since it had been so poorly tilled heretofore. The novelty in the anatomic situation with respect to feeble-mindedness seems to us to lie in the fact that we deal with all grades of defect, from an equality with brutes up to subnormality, hardly removed from ourselves, and thereby gain a number of steps upon what the comparative anatomist can ever take. It is conceded that the higher mental operations have much to do with speech,— its storage and its expression. Now, among animals few traces of speech exist. But among the feeble-minded all degrees of speech loss may in the course of years be studied. The missing links and intergrading transitions between the primates in general and man in particular may be found in feeble-mindedness. By proper sifting of cases, future investigation will discover by an accumulation of instances the minimum mechanism with which speech can be effected.

It is this principle of the minimum apparatus, the minimum machinery with which a function may be performed, that we regard as the most important and promising aspect of feeble-mindedness from the standpoint of research into mental function. As we have elsewhere sketched, fundamental researches in the psychology of efficiency may well be made with the feeble-minded, since among them we shall be able to discover what can be done with the least apparatus. For the purpose of the present argument we need not

develop the collateral fact, that in brain disease of the normal adult and in brain disease of epileptics we often deal with far more complicated problems since the destruction of a few bits of brain apparatus in one region may lead to functional disuse of great masses of mechanisms that are structurally quite intact. Diaschisis and shock are instances in point. There is no method of determining, at least in the majority of nerve cells, whether they are performing vegetative or conductive functions, or no functions whatever. Consequently the principle of discovering the minimum machinery with which a given act may be performed cannot be applied as a rule in the field of the neuropathology of destructive lesions.

Mill's method of study by means of concomitant variations is a method much more readily applied to material in feeble-mindedness than to the ordinary anatomo-clinical material of the neurological clinic.

Now, it must be conceded forthwith that, if the authorities in mental tests are in doubt as to their ultimacy, the brain anatomists are equally modest in their claims. As we looked over the claims of the workers in mental tests, we concluded that these mental tests could at least lay claim to a certain orderliness, such that a patient stated to have a mental age of six, was at all events of less mental capacity than one having a mental age of seven or eight. In short, the dicta of the mental tests might have an ordinal value if they did not possess cardinal value. Very possibly, also, this point might apply to the point-scale data of the Yerkes tests, although this perhaps was less likely on account of the fact that a given percentage in the Yerkes tests might be made up of exceedingly heterogeneous successes in puzzle-solving, the doing of sums, and the answering of questions. Conceding for the moment that the mental tests are now so good as to have approximately an ordinal value, such that a patient of eight years mental age has higher intelligence than a patient having a mental age of seven years, we can see that it might be well to compare our brains of feeble-minded subjects together so that we might learn whether here also there was an ordinal value to attach to the brains. We are, doubtless, far from the achievement of *cardinal* values, indicating definite increment of mental capacity to correspond with definite increment of brain mass, even should our studies be so minute as to permit us to evaluate the dendrite supply and synaptic surface area of the brain cells instead of their mere proportionate numbers. But might we not be able to arrange our brains in an ordinal series which would be convincing because of the derivation of the principles of arrangement from a number of sources: say, brain weight, proportionate brain weight to body length, complication of sulci, size of corpus callosum, etc., etc.?

And suppose this order of brains to be obtained, would it fit at all with the order of brains obtainable by mental tests? If the two series were largely identical, then might

not some progress be thought to have been made in the problem of the relation of intelligence to brain? We are, of course, entirely aware that this principle is applicable to a large series only, and the present tables are offered chiefly to lay down a few principles as to the proper lines of future correlation on the basis of more cases. We have placed at the head of Article II a statistical table of the ten cases in which some data for identification are given. In the following table, we again arrange the brains in their order of acquisition by the laboratory. In separate columns we place the age, mental age, brain weight (whether less or more than average according to our view), together with certain anatomical and histological data.

TABLE II.

Table Displaying Mainly Histopathological Findings, Cases I–X.

Number	Age	Mental Age	Brain Weight probably	Focal Destructive Lesion	Hydrocephalus	Exudative Lesion of Rod Cells	Nerve Cell Aplasia	Fiber Loss	Gliosis	Satellitosis	Dislocated Ganglion Cells
I	5	1–, est.	minus	0	moderate	0	marked	marked	slight	0	0
II	20	1–, est.	minus	+	marked	0	marked	marked	marked, patchy	+	0
III	45	7, est.	minus	0	0	0	+	?	+	+	0
IV	62	moron or subnormal	plus	0	+	+	+	+	+	focal	+
V	16	subnormal	normal	0	slight	0	+	0	+	0 (sl) focal	+
VI	26	2, est.	minus	0	0	+ rod cells	slight	?	+	+	0
VII	25	5, Binet	normal	thrombus (Hist.)	0	rod cells	slight	?	+	0	0
VIII	36	subnormal	normal	0	0	+	+	0	+	+	+
IX	39	7, Binet	plus	0	0	0	+	0	0	0	+, slight
X	37	24, Binet	plus	0	0	?	+	?	+	+	0

It will be seen that one case (II) is apparently the result of a focal destructive brain lesion of great size. This case was probably one of encephalitis,— possibly due to poliomyelitis,— and yielded a marked degree of hydrocephalus. This fact, however, did not complicate the estimation of its proper place in the anatomical or psychological series, since the brain was clearly upon the score of weight and simplicity not of so low grade as Case I, but lower than any other brain. Cases I and II, then, appear to be the lowest brains in point of anatomy and the lowest cases in point of intelligence. The comparison may be made even finer, since beyond question the brain of Case I was the least complex of the entire series, and the mentality of this case, whose actual age was but five years, was also minimal.

There are, however, three cases of pronounced microcephaly, namely; cases I, II, and III. The instance of Case III is the most disquieting in the analysis so far from the

standpoint of aligning the brains with estimated mental capacity. Case III, it may be remembered, was that of Little Zip, a microcephalic, who lived for forty-five years a vagrant life, which was almost self-supporting in the hobo sense of the term. With the brains superficially suggestive of a dog, the patient himself exhibited a number of doglike features in his vagrant, happy-go-lucky life, journeying from the barn or house of one friend to that of another. Arranging the brains in the order of their complexity, the brain of Little Zip must be placed third, after the microcephalic case I and the microhydrocephalic case (post-encephalitic) II, and yet the mental age of Little Zip may be safely estimated as about seven years. The mental age is, at all events, much higher than that of the other microcephalics. Thus, if the brains are arranged in order of their estimated age, the brain of Little Zip comes in sixth or seventh place, instead of in the third place.

Another case (IX) may be chosen as well illustrating the possibility of wrongly estimating the mental capacity of a patient from his brain appearances; for this brain was placed upon the score of its complexity, largely in the gross, in the fifth place. Its mental age was seven. Yet two brains that are regarded as still more complex, namely; those of Cases X and VII, yielded Binet ages of $2\frac{1}{5}$ and 5 respectively. The microscopy of Case IX, however, should that be taken into account, would insure a somewhat lower place for the brain of this able-bodied imbecile, of great stature and large, poorly-molded brain (1620 grams; more than 200 grams in excess of an estimated norm). The examples of Little Zip (Case III) and of the able-bodied imbecile (Case IX) suffice to indicate the difficulties of these analyses.

The following table (Table III) shows the brains arranged in the order of their estimated complexity, and the figures in the intelligence column will readily demonstrate the facts just mentioned, concerning the dislocation of cases III and IX from their proper places in the series if we estimated the brains on their gross complexity alone.

TABLE III.

Comparison of Brain Complexity, Brain Weight, and Order of Intelligence in Cases I–X.

Number	Age	Brain Complexity	Brain Weight	Intelligence
I	5	a)	400–, est.	1–, est.
II	20	b)	620	1–, est.
III	45	c)	610	7, est.
VI	26	d)	1130	2, est.
IX	39	e)	1620	7, Binet
X	37	f) or g)	1450	2.4, Binet
VII	25	f) or g)	1270	5, Binet
IV	62	h)	1340	Moron or subnormal
V	16	i) or j)	1435	Subnormal
VIII	36	i) or j)	1340	Subnormal

Table IV arranges the brains in the order of actual brain weight, but gives also the brain weights estimated by Tigges's formula (eight times the body length in centimeters = brain weight in grams). The brain weight for the normal age and sex of the individual taken from Vierordt's tables is also given.

TABLE IV.

Comparison of Brain Weight, Corrected Brain Weights, and Order of Intelligence in Cases I–X. (Arranged in order of actual brain weight).

Number, Age, Height (cm.)	Brain Weight Tigges	Brain Weight Age normal (Sex)	Brain Weight Actual	Intelligence
I, 5, 81	648	1282, M	400–, est.	1–, est.
III, 45, 126	1008	1348–66, M	610	7, est.
II, 20, subn.	?	1358–96, M	620	1–, est.
VI, 26, 158	1264	1358–96, M	1130	2, est.
VII, 25, 146	1168	1234–39, F	1270	5, Binet
IV, 62, 141	1128	1178–1210, F	1340	Moron or subnormal
VIII, 36, 179	1432	1365–6, M	1340	Subnormal
V, 16, 168	1344	1358–96, M	1435	Subnormal
X, 37, 144	1152	1365–6, M	1450	2.4, Binet
IX, 39, 178	1424	1365–6, M	1620	7, Binet

Table V presents the cases in the order of their estimated intelligence.

TABLE V.

Comparison of Order of Intelligence with Complexity of Brain in Cases I–X.

Number	Actual Age	Intelligence	Brain Complexity	Remarks
I	5	1–, est.	a)	
II	20	1–, est.	b)	
VI	26	2, est.	d)	Vocal cord absent
X	37	2.4, Binet	f) or g)	
VII	25	5, Binet	f) or g)	
IX	39	7, Binet	e)	*Out of place*
III	45	7, est.	c)	"Zip," out of place!
IV	62	Moron or subnormal	h)	Almshouse transfer
V	16	Subnormal	i) or j)	Dementia praecox
VIII	36	Subnormal	i) or j)	Murderer

It seems safe to conclude from these tables that at least the brains of least complexity are correlated with the minds of least range, and that the brains of greater complexity are in a general way correlated with minds of greater range. By microscopic correction of the anatomical decisions, we may even cause our figures to look still more satisfactory from the standpoint of identical ordering of anatomical and psychological data. Whether

the future may show how to account for the apparent too-great simplicity of the brain of Little Zip, remains to be seen.

The second point in our epicritical review may be presented briefly, partly on the basis of Table II, in which the findings of exudative lesion or rod cells are entered, and also by means of Table VI, in which are displayed the majority of the anatomical findings in the series. How many of our cases may be regarded as essentially preventable by the means theoretically available to the mental or psychiatric hygiene of the individual, leaving out, that is to say, the eugenic line of attack? Let us, perhaps, grant that Case II, with its focal destructive lesion,— possibly of post-encephalitic origin,— its marked hydrocephalus, marked nerve cell and fibre loss, and marked patchy gliosis, with its focal microgyria in other regions than the most marked post-encephalitic lesion, is a case that is preventable,— that is by social and scientific devices which shall exclude this presumably infectious disease from occurring.

If we take at their face value the slight mononucleosis of cases IV, VI, VIII, and X, we may perhaps consider them as either syphilitic or as suffering from progressive exudative disease of a mild nature, also theoretically preventable. Now, in point of fact, we are far from proving that these four cases are cases of syphilis; or that Case VII, a case which fails to demonstrate lymphocytosis but does demonstrate rod cells, is a case of syphilis. It is, however, of importance to consider that in a series of ten cases of numerous grades of feeble-mindedness, no less than six show processes of a suspiciously progressive nature or suggestive of infection. Here is a problem that is well worth working out in the utmost detail, whether we lay down the problem as a problem of the frequency and distribution of syphilis in the feeble-minded, or whether we seek to establish the part played in feeble-mindedness by acquired disease.

Let us sum up these considerations by saying that the number of cases in which the hypothesis of infection must be more or less firmly entertained is much larger than has been supposed. By consequence, the scales tip much farther for the group of the so-called secondary amentias than was the supposition with most workers.

In addition to these main points in our epicritical review, namely; the point concerning the relation of the complexity of brain to capacity of mind, and the point concerning the theoretical preventability of certain cases, we should not dismiss our review without slightly indicating the richness of the field in points of interest to neurology. The teratologist and embryologist are sufficiently aware of these values, so that we need not make special point of the *Affenspalte* question (for instance, Case I and Case III); the question of cruciate asymmetry (Case V), the question of the absence of the middle commissure (Cases V, VII, IX, and X), the question of presence of dislocated ganglion cells in the white matter

TABLE VI.

Case Number	Calvarium	Dura Mater	Pia Mater	Vessels	Brain Weight Grams	Gyri	Diffuse Atrophy or Aplasia	Focal Atrophy or Aplasia	Corpus Callosum
I	———	———	slight general thickening	negative	400, est.	Microcephaly	marked	variations; "affenspalte" left	proportionate
II	thick frontal; depressions	normal	normal	negative	620	Microcephaly	marked	microgyria, 2nd frontal, etc.	thin
III	moderately	normal	normal	negative; except vertebrals	610	Microcephaly	marked	minor anomalies	proportionate
IV	dense	slight thick, frontal	slight thick, vertex	negative	1340	Focal microgyria and asymmetry	no	minor anomalies	rather thin
V	negative	negative	slight general clouding vertex	negative	1435	Cruciate asymmetry	absent	frontal; opercular	slightly thin, posterior third
VI	inequalities of thickness, brittle	thick along middle meningeals	slight general thickening	negative	1130	simple, symmetrical	absent	Frontal	thin throughout
VII	dense	adherent at corono-sagittal suture line	faintly hazy, vertex and sulci	negative	1270	slight asymmetry; simple construction	absent	Frontal	thin, horizontal portion
VIII	———	———	thickened	negative	1340	slight asymmetry; transverse gyri	absent	left parietal	moderate thining, posterior third
IX	thick, somewhat dense	thick	focal basal leptomeningitis	negative	1620	slight asymmetry; "poorly moulded"	absent	absent	narrow, posterior third
X	dense	focal thickening	cerebellar pia thickened; pia in general thick	negative	1450	slight asymmetry	general superficial	Frontal	slight thinning, posterior third

TABLE VI (*continued*).

Middle Commissure	Consistence	Sclerotic Foci	Other Foci Destructive	Ventricles Hydro-Cephalus	Cerebellum	Spinal Cord	Remarks
———	———	absent	———	moderate	negative	———	
———	not remarkable	———	left parietal	marked	negative	negative	early focal encephalitis, (poliomyelitic?)
———	not remarkable	absent	absent	0	inferior vermis absent?	negative	
———	not remarkable	absent	absent	present	dentate nuclei unequal		mononucleosis, posterior septum, spinal cord
absent	normal	absent	acquired? slight lesion, left callo-so-marginal	slight	negative	negative	
———	normal in general	left 2nd temporal firm, yellow	absent	0	negative	negative	rod cells; lymphocytes in smear, frontal
absent	normal	absent	canalized thrombus (histologically)	0?	negative	negative	rod cells
present	———	absent	absent	0	negative	———	plasmocytosis, focal, left prefrontal
absent	normal; putty-like at base	absent	absent	0	negative	———	
absent	unusually firm; "brain swelling"	absent	absent	0	small	negative	?mononucleosis, focal, right postcentral (dead of pellagra; tuberculous)

(Cases IV and V, and to a slight degree, Case IX), the problem of the time relations of satellitosis (as shown in cases II, III, VI, VIII, and X; and focally, in IV and V), and the question of defective cortex lamina (as shown characteristically in Case IX). We choose for exposition a somewhat more recondite point, namely; the significance of hydrocephalus in some of these cases.

The significance of hydrocephalus in Cases I and II with microcephalic brains is hard to judge. Whether the microcephaly is due to hypoplasia or to agenesia, it would naturally not be unlikely that there should be an absence of neurones, both on the exterior and in the interior, or both in the outer and inner portions of the brain substance. Accordingly the hydrocephalus exhibited in the brains of Cases I and II is not necessarily to be associated with increase of intracranial pressure at any time in the lives of the patients. The hydrocephalus in Case II is very possibly to be related with an early focal acquired lesion of the nervous system (paralytic shock stated to have occurred at three months of age by attending physician). The hydrocephalus in Case III is possibly to be explained similarly, and does not require the hypothesis of heightened intracranial pressure at any time in the life of the patient.

Aside from hydrocephalus associated with microcephaly, and possibly due to the operation of identical causes, we must consider on another basis the hydrocephalus of four other cases: IV, V, VII, and X.

The hydrocephalus of Case IV is voluminous and is associated with a corpus callosum rather thinner than normal, and in fact very thin posteriorly opposite the region of greatest ventricular dilatation. The motor restlessness of this case may or may not be correlated with the ventricular dilatation, as has been contended by Southard in his work on dementia praecox in 1915, and in a later analysis of hydrocephalus in the so-called functional psychoses, as yet unpublished. However, it may well seem to the anatomist that the hydrocephalus would best be regarded as one due to tissue atrophy of a gradual nature, not in any wise necessarily related to alterations of intracranial pressure. The external features of the brain do not show recent effects of ventricular swelling. Accordingly, we should not lay particular stress on the occurrence of ventricular dilatation associated with motor restlessness in Case IV.

Case V shows dilatation of the right lateral ventricle without dilatation of the left (in fact, there may have been a slight degree of internal brain swelling which has caused the surfaces of the left ventricle to come into apposition). This finding of unilateral hydrocephalus has not been infrequent in Southard's dementia praecox series of 1915; has been there referred to at length, and also in the later, as yet unpublished, analysis. In cases VII and X, we are dealing neither with pronounced microcephaly (the brain weights

respectively are 1270 and 1450 grams, accordingly over weight according to Tigges' formula of brain weight in grams equal to eight times the body length in centimeters), nor with the special conditions of a possibly atrophic brain in an imbecile of 62 years, Case IV, and the special features of the case of dementia praecox, Case V. Cases VII and X, curiously enough from our present standpoint, are examples of such an imbecile as is rather apt to be termed by the laymen insane, or "crazy", imbecile. The point of the attendant's or layman's remark is not that such an imbecile belongs in the group of the psychoses as the physician views them, but that the patient is insane or "crazy" from the nonmedical standpoint; showing spells of marked irritability. Thus, Case VII is described as having had tantrums, as being "hysterical" on examination, laughing one minute and crying the next, rushing about, jumping up and down, and screaming on occasion, and was regarded as a very troublesome case.

Case X is described as having been somewhat feeble on admission to the school at the age of 10 years, but as later becoming very troublesome, with quick temper and noisiness.

This problem of the relation of hydrocephalus to hyperkinesis, as first developed from Southard's dementia praecox work of 1915, can hardly be settled in its relation to feeble-mindedness from this series, for if we exclude the three markedly microcephalic cases (Cases I, II, and III), the old demented imbecile (Case IV), the case of dementia praecox (CaseV), and the executed murderer (Case VIII), we are left with but four cases: VI, VII, IX, and X, of which VII and X were hydrocephalic and had been as sketched above as to their tendencies to over-activity. If we consider in contrast to these VI and IX, (the cases we have termed "typical idiot" and "peculiar imbecile" with some capacities above the imbecile grade), we find ourselves dealing with brains of simple construction and of poor moulding respectively, in which brains there is no evidence of hydrocephalus despite the fact that the brains show the corpus callosum in both instances to be thinned out posteriorly. (In fact, the corpus callosum of Case VI is everywhere rather thinner than usual.) Case VI was a very restless and nervous idiot, described as "always looking around," and as "inclined to be destructive". It appears that these tendencies were constant and not more marked at one time than another. The case seemed to be one of slight microcephaly (brain weight, 1130, is 134 grams under Tigges' formula for the patient's height, 158 cm.). "Constant nervousness" or hyperkinesis can hardly be supposed to be associated with hydrocephalus except accidentally and independently of any casual interrelation. The point of the coexistence of overactivity and hydrocephalus in the microcephalic would lodge rather in the simplicity of the neuronic system in the microcephalic case. It is clear that, if the microcephalic brain is *also* hydrocephalic, the neuronic systems of the brain in question must be still simpler in make-up. If the brain in question is

taking in anything like the normal number of ingoing stimuli, and the capacity of the brain to dampen or inhibit the stimuli and divert them from taking effect in motion, is a diminishing capacity, then over-activity becomes the most natural result of the simplicity of the brain and one quite to be expected.

Accordingly, although the typical idiot(Case VI) yielded a brain without hydrocephalus and yet was over-active, it is clear that the over-activity is not of the type of the occasional hysterical outburst; thus, whereas Cases VII and X are described as excitable, Case VI would best be described as restless or "nervous".

Case IX showed no restlessness or excitability at any time, having a good disposition and in general a rather coöperative nature.

Our problem, accordingly, as based on the analysis of this group of cases from the standpoint of hydrocephalus, may be summed up as follows:

The association of internal hydrocephalus with microcephaly may well be incident to the mal-development, that is to say, merely a part of the result of the factors which have retarded or stopped the growth of the brain. Accordingly, under these circumstances, alterations of intracranial pressure are neither necessary nor in fact very likely to occur. Moreover, dilatation of the ventricles in old age and in dementia praecox must be considered separately. If there is any relation between occasional outbursts of excitability and alterations of intracranial pressure which have to do with the production of hydrocephalus, many more cases will be necessary to make the point certain. We have one good instance to show that *constant* restlessness is not necessarily associated with hydrocephalus. A further physiological and psychological analysis of the difference between excitability and restlessness would be very desirable, both for its intrinsic interest and for the light it may throw upon these structural conditions, which are difficult, if not impossible to interpret when considered entirely by themselves.

Summary.

The entirely provisional conclusions of the epicritical review may be briefly stated as follows:

First, it is not impossible that the problem of matching brain complexity with mental capacity may be solved by a much larger series of instances than is here available; but the instances of such matching as has been undertaken are somewhat convincing as to the correlations of low orders of intelligence with simple brains and of higher orders of intelligence with more complex brains. Occasional exceptions to the rule may be explained by

the finer anatomy of certain cases (Case IX); others remain less easy to explain away (Case III).

Secondly, the partial orienting and microscopic examination yielded more instances of slight exudative lesions (including in some instances rod cells) than might have been *à priori* expected from a relatively stable institutional material like that here largely drawn upon. What the share of syphilis in this group of cases may really be is doubtful. There was one instance of feeble-mindedness very possibly due to an early focal encephalitis entailing mal-development of brain.

Thirdly, as an example of special neurological interest attaching to this study, some considerations about hydrocephalus offered bring up the question of the relation between occasional bursts of excitability and alterations of intracranial pressure with the production of hydrocephalus.

Description of Photographs.

Views of Case I.

The gross photographs of the stripped brain alone are presented since, although there was a slight general thickening of the pia mater, the microscopy of the tissue has so far shown no evidence of exudate.

Note in photographs I–a, I–c, and I–d the striking projection of the cerebellum behind the occipital poles. Note the suggestion of *Affenspalte* (I–a).

Note in I–b the large exposure of the crura cerebri, as well as the comparatively small number of transverse pontine fibres arranged in almost distinct bundles. Note, also, in I–b the comparative size of the optic tracts and olivary eminences.

Note in I–a, I–c, and I–d the bi-convolute construction of the frontal lobe; the superior frontal convolution, broader than the inferior, may represent superior and middle frontal convolutions of more highly developed brains. Note the excellent development of the pyriform lobule on each side, especially the right (I–b).

We present in I–e, I–f, and I–g, three views of the brain in total section as stained by the Weigert myelin sheath method. (Note that the stains are relatively successful despite the preservation of the brain for eleven years in formaldehyde solution.) A moderate degree of hydrocephalus is notable in I–f. The small size of the leaflets of the cerebellum is to be noted in I–g. The comparatively greater depth of the sulci than those found in more normal brains is obvious in each of the total brain section views.

This case is thought to have possessed the lowest mental age in the entire series. An older sister of the patient was almost equally defective and almost identically microcephalic; other children, before and after, were not microcephalic.

Views of Case II.

The gross photographs of the stripped brain alone are presented since the membranes were normal and there were no microscopic evidences of exudative disease.

Photograph II–a demonstrates the focal posterior-lying areas, especially marked on the left side with microgyria. This case of microcephaly exhibits a higher degree of hydrocephalus than did Case I, as is demonstrable from the total brain sections II–f, II–g, and II–h. II–a also shows frontal depressions corresponding with depressions in the skull. Note in II–a, II–c, and II–d the distinct projection of the cerebellum behind the occipital poles; a projection less marked than in Case I.

Note in II–c an area of microgyria in the second frontal gyrus; a similar area is less marked in II–d. II–a demonstrates that the area of microgyria begins almost abruptly with the postcentral gyrus; whereas the precentral gyrus on each side is of fair width and well rounded. Photographs II–c and II–d demonstrate that the microgyria is far less marked on the flanks and inferiorly than superiorly; and this contrast is strongly brought out in the total brain section view, II–g and II–h.

The mental age of this case was, also, one year or less, but the intelligence of the patient was greater than that of Case I. Clinical observation of the patient's general behavior indicated that he was in the habit of attending to bright colors, looking at pictures, watching boys at play, and taking interest in events about him. The question arises, whether these functions are largely related so far as they are of visual origin with the inferior rather than the superior tissues of the occipital lobe. It may be noted that the Weigert myelin sheath stains are relatively successful with this brain although it was preserved in formaldehyde for 13 years.

Views of Case III.

The views of this case are, also, limited to the stripped brain for the same reasons as in Cases I and II. Note the general symmetry of this brain. The views do not include the cerebellum, which, however, did not project beyond the plane of the occipital poles. Note in III–a the suggestion of *Affenspalte* on the right side.

Note that the gyri are everywhere narrow and simple in arrangement, and that the secondary sulci are rarely complicated by collaterals. A special description in the text is made of the parietal regions, which in III–a are quite unlike.

III–c and III–d show at the base of the frontal gyri, separating them from the precentral convolutions, short, deep, transverse sulci, somewhat suggesting the sulcus cruciatus of the brain of a dog. Note, in fact, the somewhat general superficial resemblance of the brain of this case to that of a dog.

Views of Case IV.

Views IV–a and IV–b are presented of the unstripped brain viewed from above and below, partly because there is a slight thickening of the pia mater at the vertex, and partly because microscopic examination showed a mononucleosis of the posterior septum of the spinal cord, which naturally gives rise to the suspicion of former syphilis, although it

fails to prove the existence of syphilis. IV–c and IV–d show the same aspects with the pia mater stripped.

IV–c, IV–e, IV–f show a lack of division of the primary sulci of the frontal lobe on account of the interruption of annectants. The parietal convolutions are also narrow: IV–c, IV–e, IV–f.

IV–d shows a right pyriform lobule larger and more prominent than the left. Now, the left side of the brain in general appears slightly more hypoplastic (or atrophic?) than the right, so that Case IV exhibits a diminution of the crossed and uncrossed systems on the same side of the brain. (We here proceed upon the basis that the connections of the left pyriform lobule are largely with the left olfactory zone, whereas the connections of the neopalium are largely crossed.) Compare, accordingly, the cruciate asymmetry which appears in Case V. We might argue that the conditions in Case IV are of more recent origin than those of Case V. At least, if we desire to attribute the cruciate asymmetry of Case V to the operation of a single agent at or before the beginning of decussation, of course this case,— the oldest in the series,— was microscopically found subject to gliosis, and the whole brain shows a tendency to atrophy with slightly flaring sulci. It may be that the condition is one of atrophy and not of aplasia, and that the atrophy has little or nothing to do with the feeble-mindedness of the case.

The gross sections are presented with some completeness (four views, IV–g to IV–j) for the reason of the somewhat surprising degree of hydrocephalus which the external views would hardly give one cause for suspecting.

The best argument for feeble-mindedness in this case is microscopic, namely; the presence of dislocated ganglion cells in the white matter.

Views of Case V.

The unstripped views of Case V are omitted, as in several previous cases, because of the lack of acute or progressive exudative process.

V–a presents the not unusual frontal and occipital cruciate asymmetry. In this instance, the left frontal and left occipital lobes are smaller than their fellows. The mesial views V–g and V–h show a slight amount of thinning out in the posterior third of the corpus callosum.

As in Case IV, the best argument for feeble-mindedness in this case is microscopic, namely; the presence of dislocated ganglion cells in the white matter. Naturally, this argument may not be convincing. In general, the gross findings in the case resemble

those of dementia praecox in their mildness and unilaterality. These appearances are borne out in a cross section (V–d).

Views of Case VI.

Unstripped appearances from above and below are presented in VI–a and VI–b, because there was not only a general thickening of slight degree of the pia mater, but lymphocytes were found in a smear from the frontal region as well as a few rod cells in certain areas. These appearances may well suggest syphilis. But one focus of perivascular lymphocytosis has been found in the microscopic study, which was in this instance chiefly limited to the stripped brain. Despite the indication of syphilis, this case was a rather typical instance of a "grinning idiot", who was perhaps classed too low under the Binet test because of his aphasia, which aphasia may have been in part due to the absence of one vocal cord. There were certain other suspicions of syphilis in the case. The corpus callosum was thin throughout (see especially VI–g and VI–h).

Views of Case VII.

The unstripped appearances in Case VII, viewed from above and from below, are likewise shown, although the pia mater was but faintly hazy throughout. The microscopic examination, however, demonstrated rod cells, from which may perhaps be suspected a more progressive condition than is assumed to be typical of feeble-mindedness. The mental age of this case, though set at five, seemed too high in a number of respects. The case also showed some sensory disorder. As in Case VI, there was apparently a suspicion of syphilis.

The views of the stripped brain exhibit a fairly complex construction. The cross sections, VII–g and VII–h, show a narrow corpus callosum.

Views of Case VIII.

On account of the focal plasmocytosis of the left prefrontal area, the unstripped views of the vertex (VIII–a), the left flank (VIII–b), and the left mesial surface (VIII–c) are presented. There was no suspicion of syphilis in this case clinically, and it may be that the condition found is due to some other intercurrent condition, which may possibly have set in even after the crime for which the patient was executed. The stripped appearances show a number of transversely directed gyri and a failure to approximate on the part of the summits of numerous gyri. This is especially shown in the view of the left flank (VIII–b).

Perhaps the strongest argument for feeble-mindedness in the case is the dislocated ganglion cells in the white matter of certain areas (very few). The narrowing of the posterior third of the corpus callosum is best shown in the mesial views VIII–c, VIII–e; less well in VIII–f, VIII–g, VIII–h, and VIII–i.

Views of Case IX.

The unstripped appearances in Case IX are presented from above and below (IX–a and IX–b) and mesially (IX–c and IX–d) to exhibit a focal leptomeningitis. especially at the base. But there was no evidence of acute or chronic inflammation microscopically.

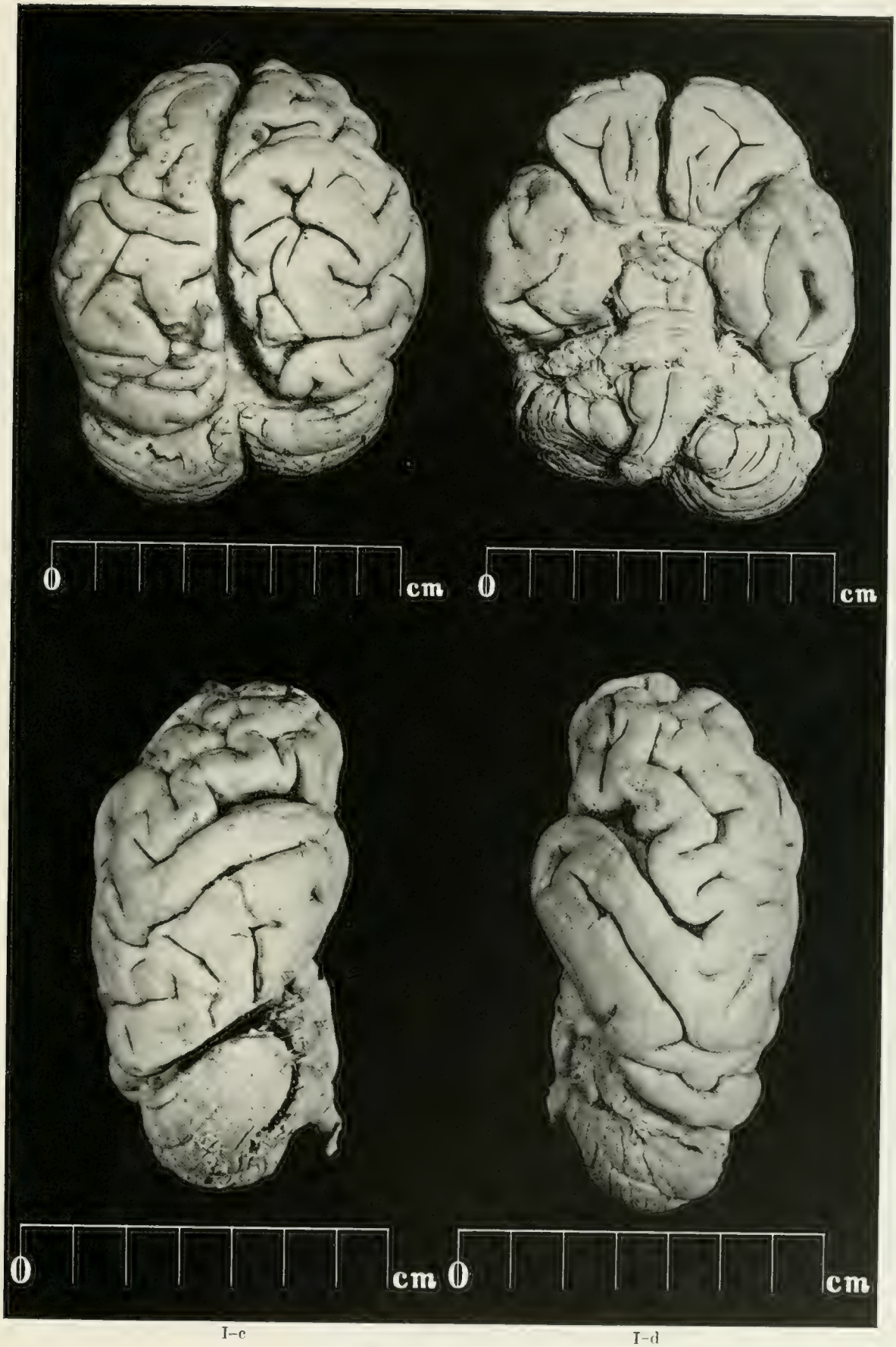
The stripped appearances (IX–e to IX–j) show slight asymmetry and a brain in general of great size but poor molding. The mesial views (IX–i and IX–j) show a narrowing of the posterior third of the corpus callosum.

Views of the brain in cross section are shown with comparative fulness on account of the irregularity in the distribution of hypoplasia as suggested by the microscopic examination. Especially the right superior frontal region (IX–k) exhibited the most marked architectural disturbance microscopically. A cyst-like area in the right hemisphere of IX–l is due to artifact.

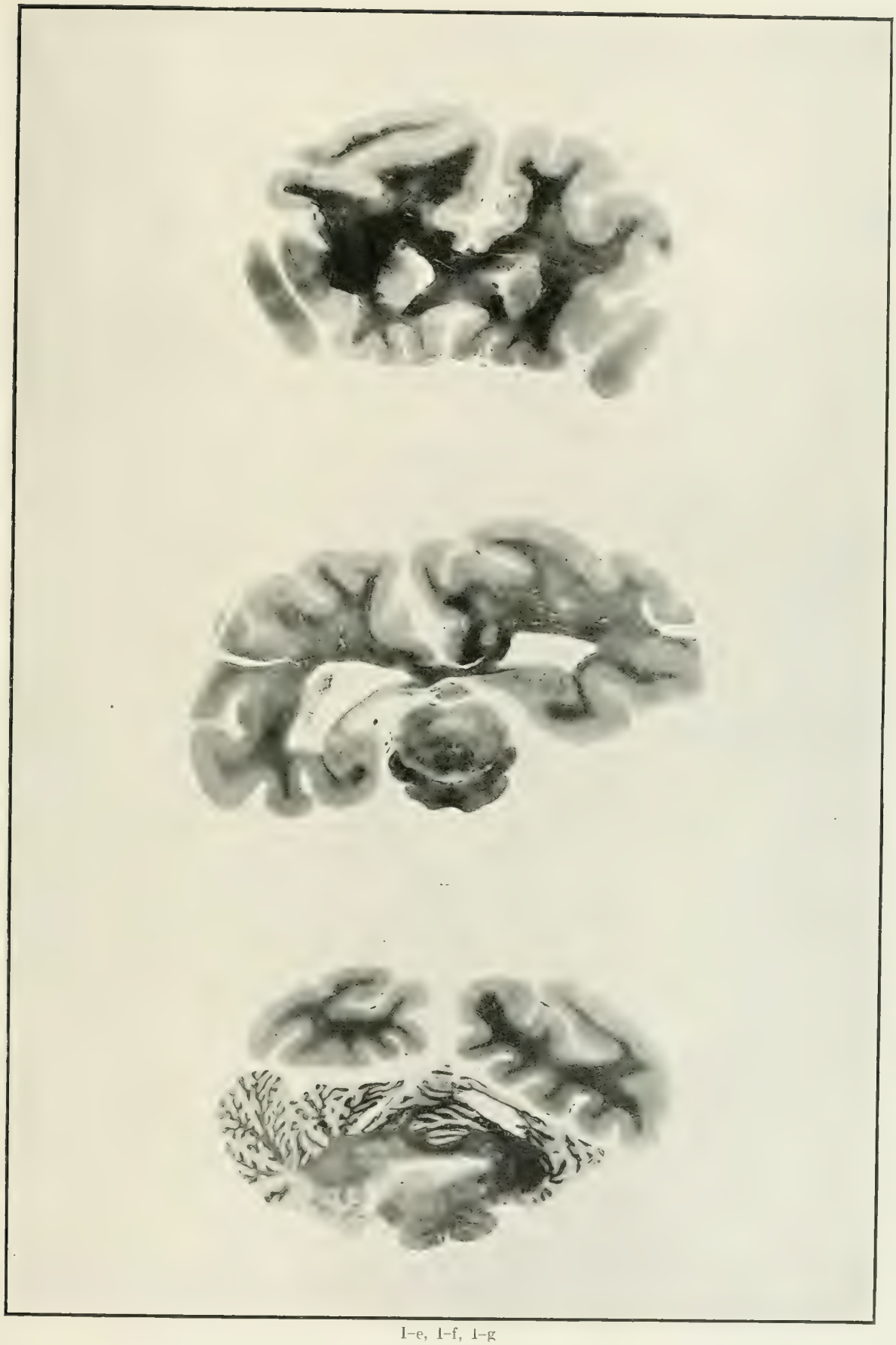
Views of Case X.

Photograph X–a illustrates the unstripped appearances, to which are added X–b and X–c to illustrate the thickening of the cerebellar pia mater. The case exhibited a somewhat questionable focal mononucleosis about the vessels of one region.

Microscopic examination showed numerical hyperplasia of cells in a number of places. The brain is fairly complex in construction, but the corpus callosum (X–h and X–i) shows a slight thinning in the posterior third.

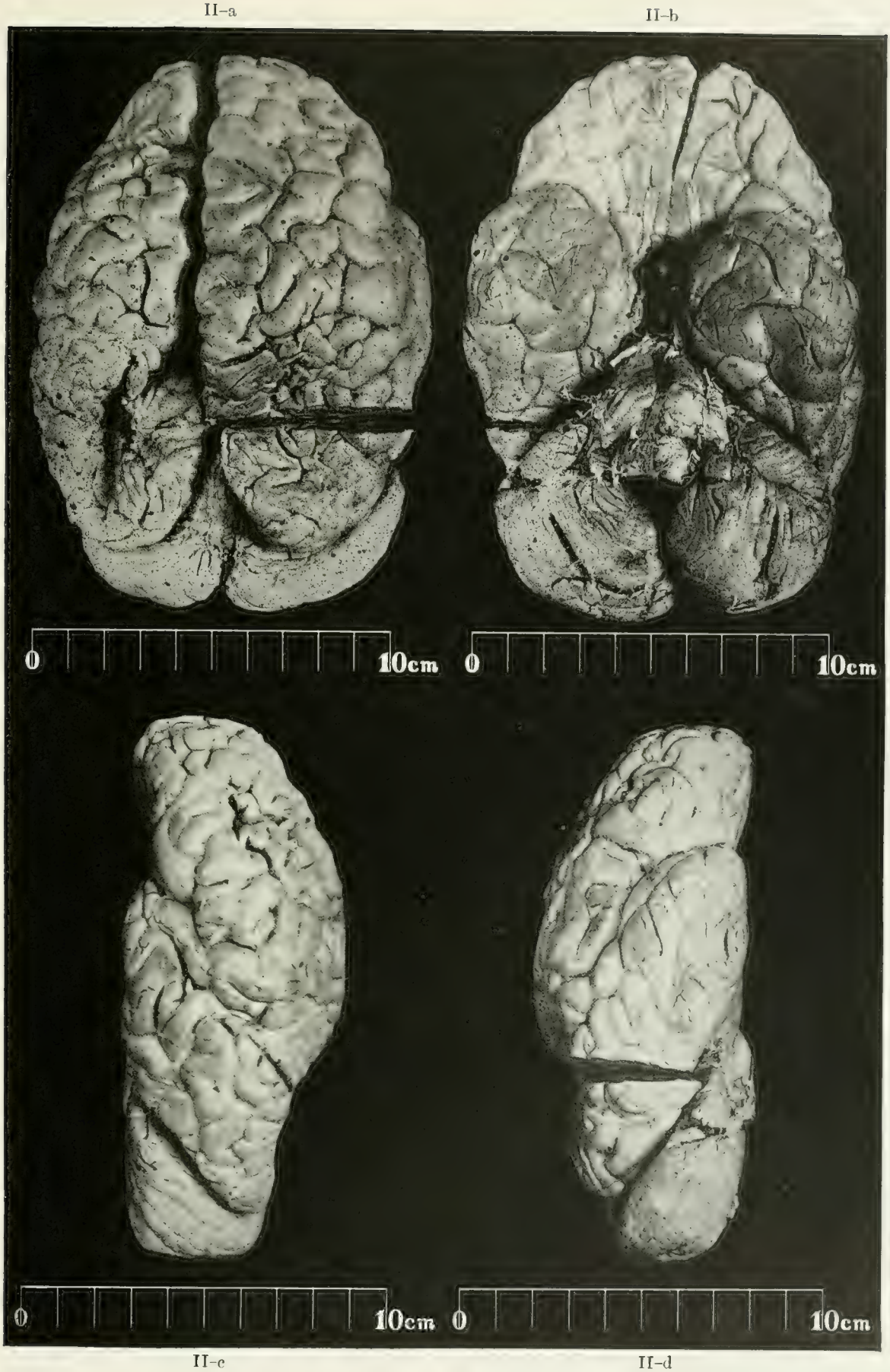


CASE I — MICROCEPHALY. LOW IDIOT



1–e, 1–f, 1–g

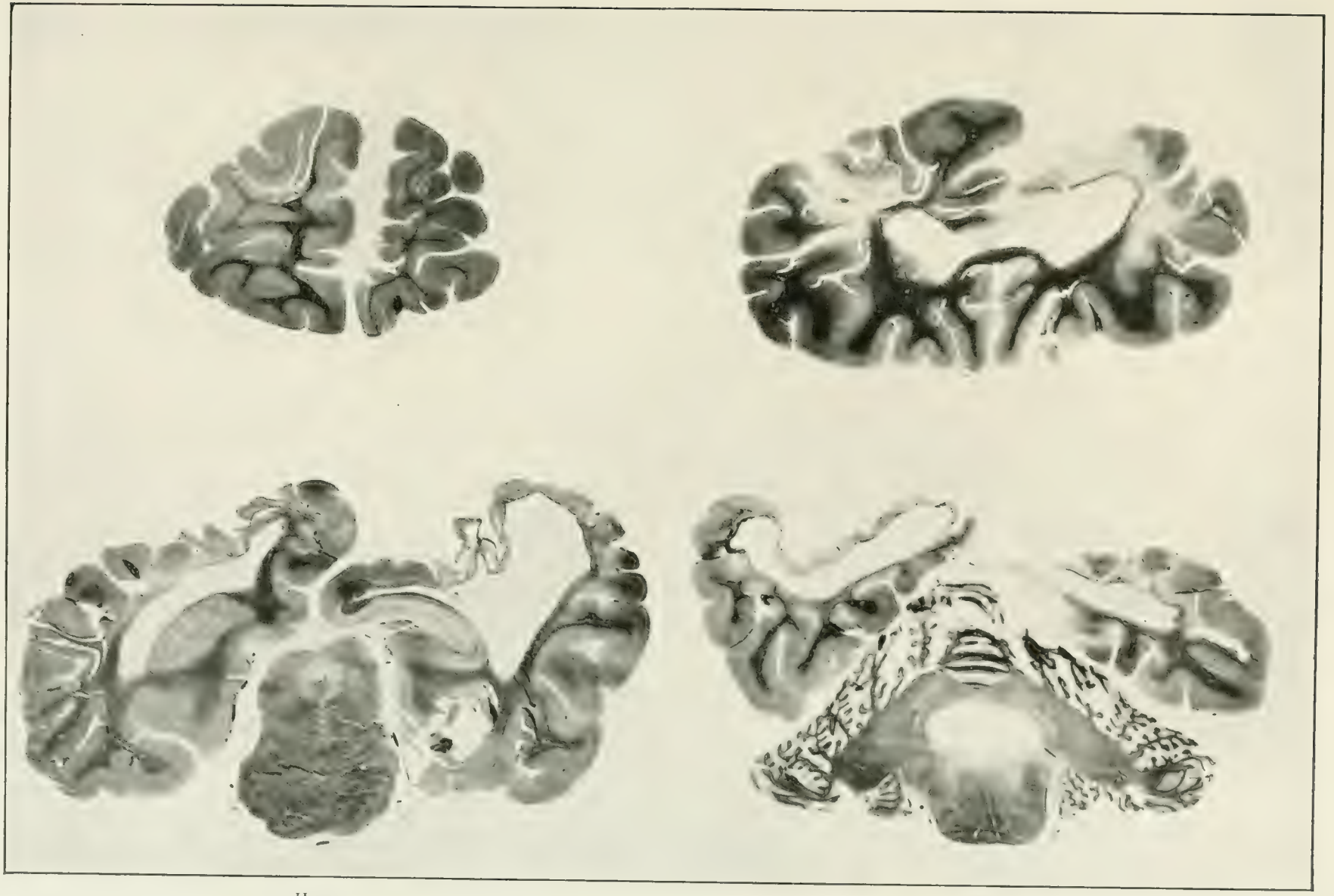
CASE I — MICROCEPHALY. LOW IDIOT



CASE II — MICROCEPHALY, ENCEPHALITIC. LOW IDIOT

II-e

II f

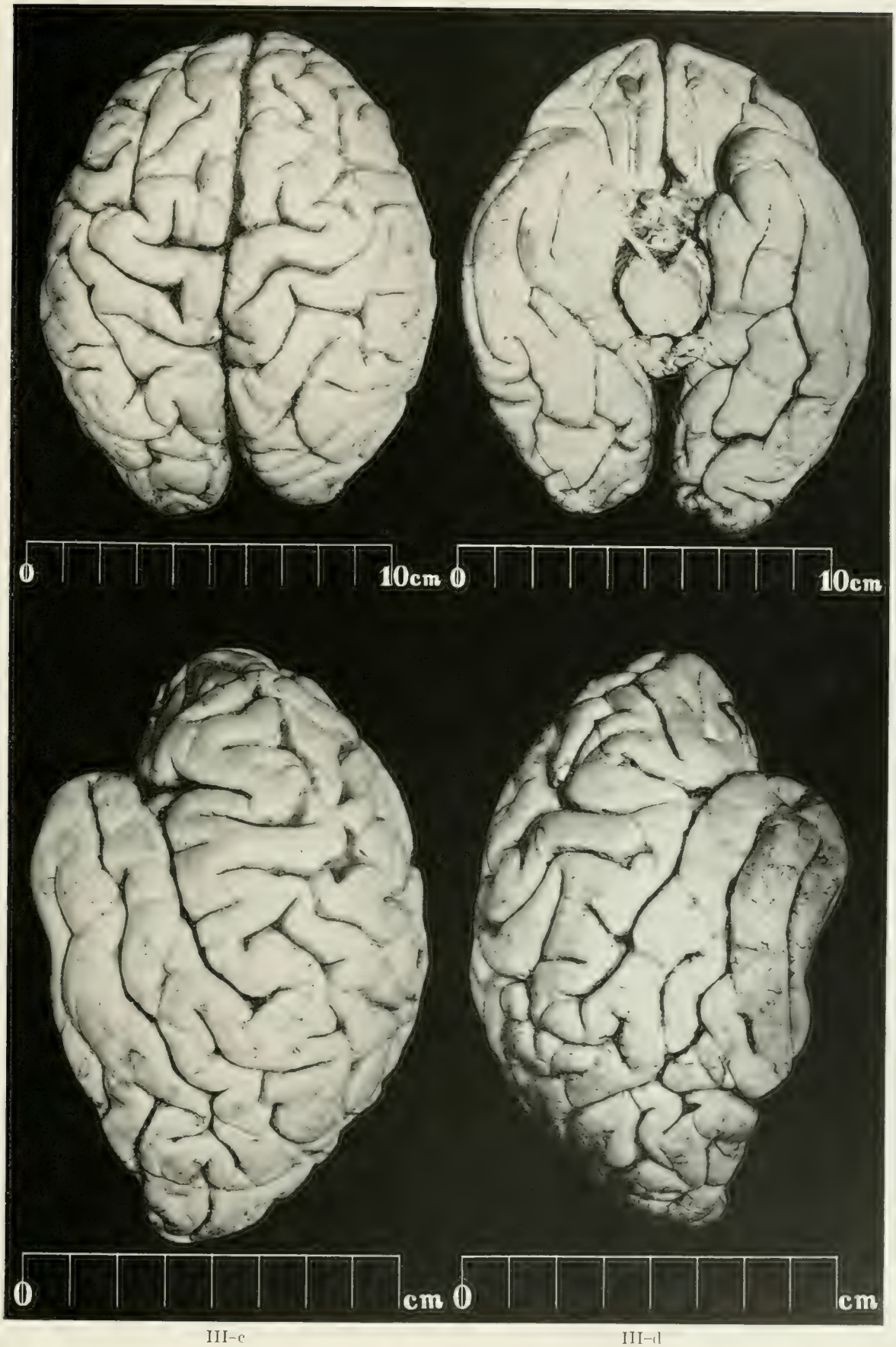


II-g

II h

CASE II — MICROCEPHALY. ENCEPHALITIC. LOW IDIOT

III–a III–b

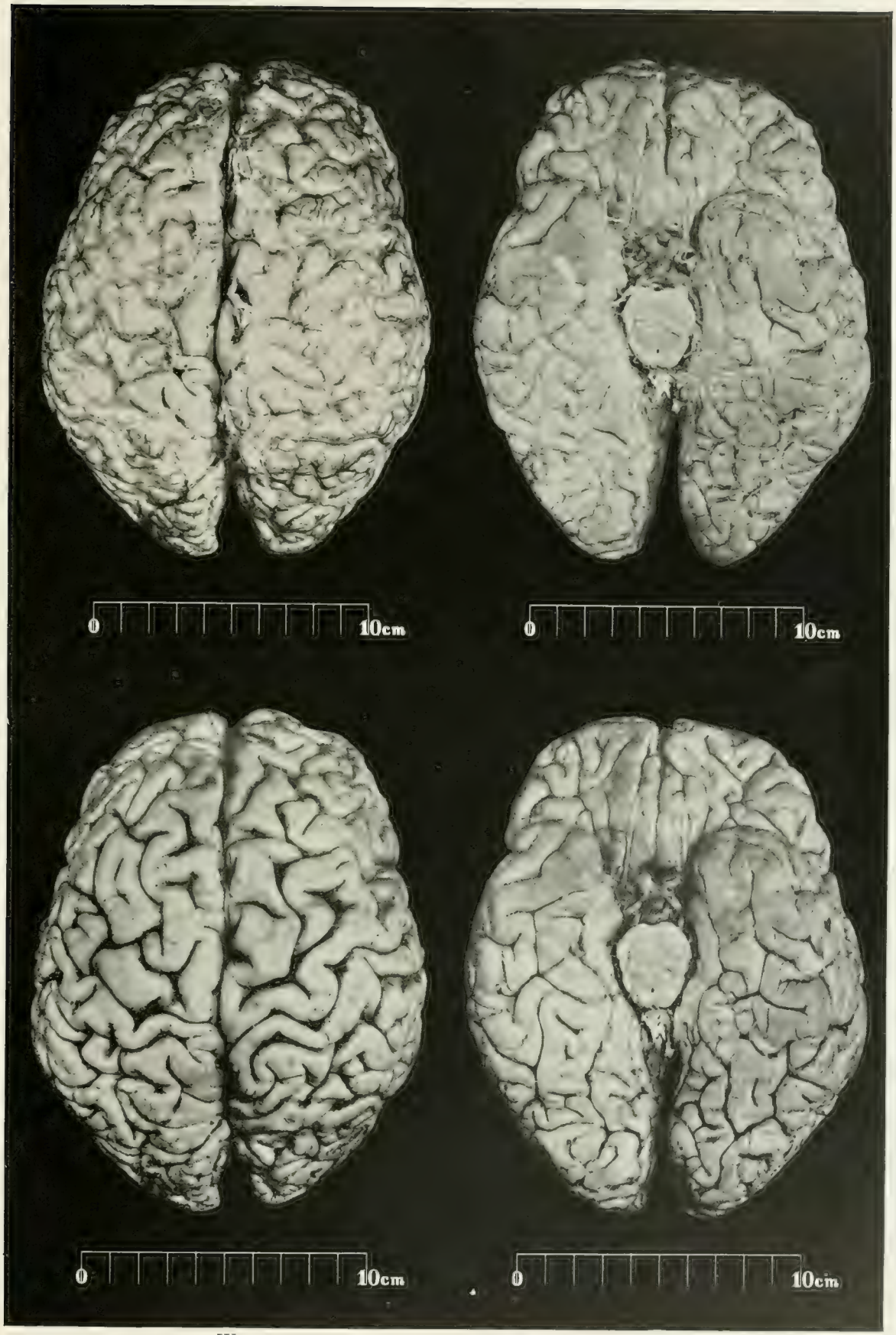


III–c III–d

CASE III — MICROCEPHALY. IMBECILE "LITTLE ZIP"

IV–a

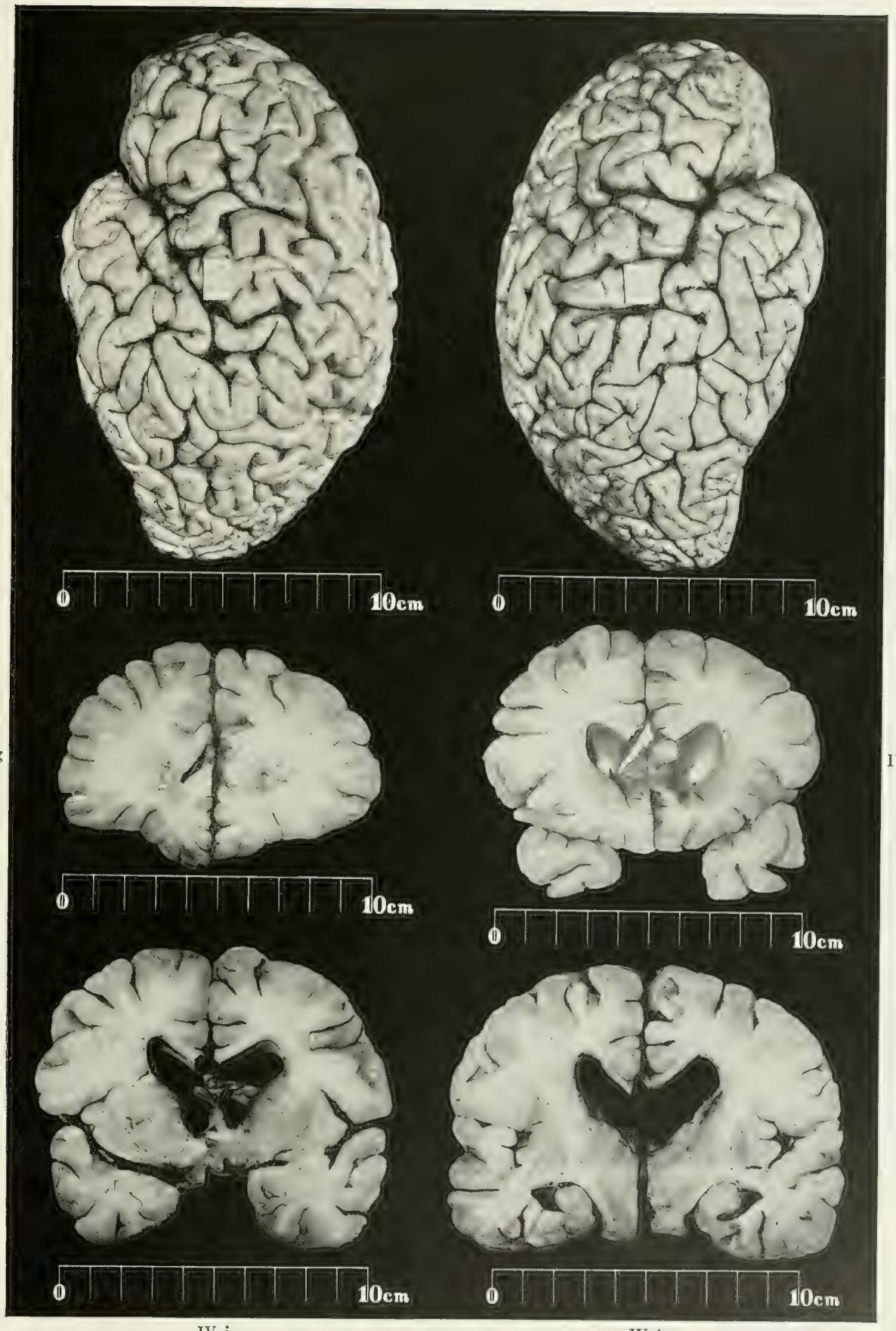
IV–b



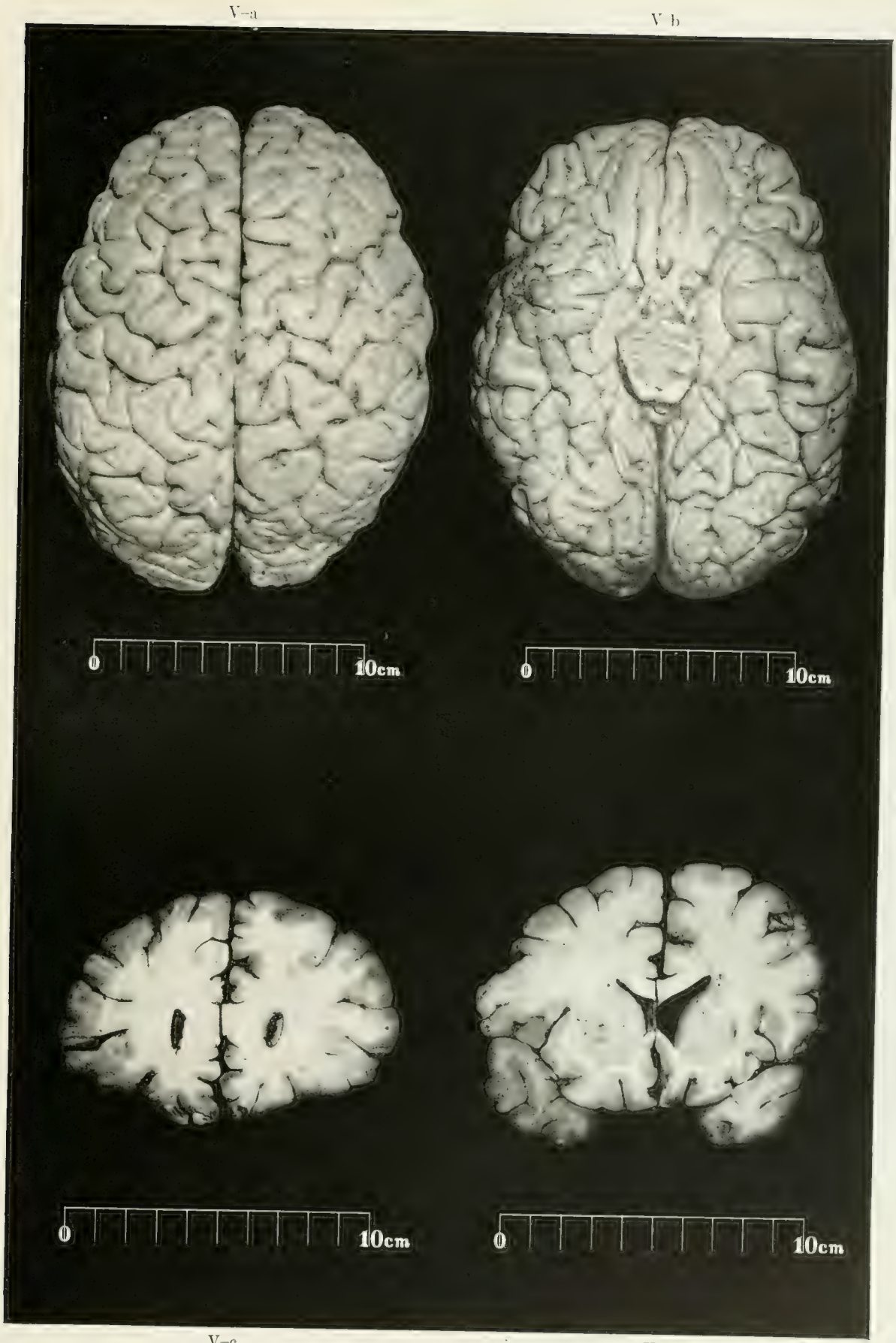
IV–c

IV–d

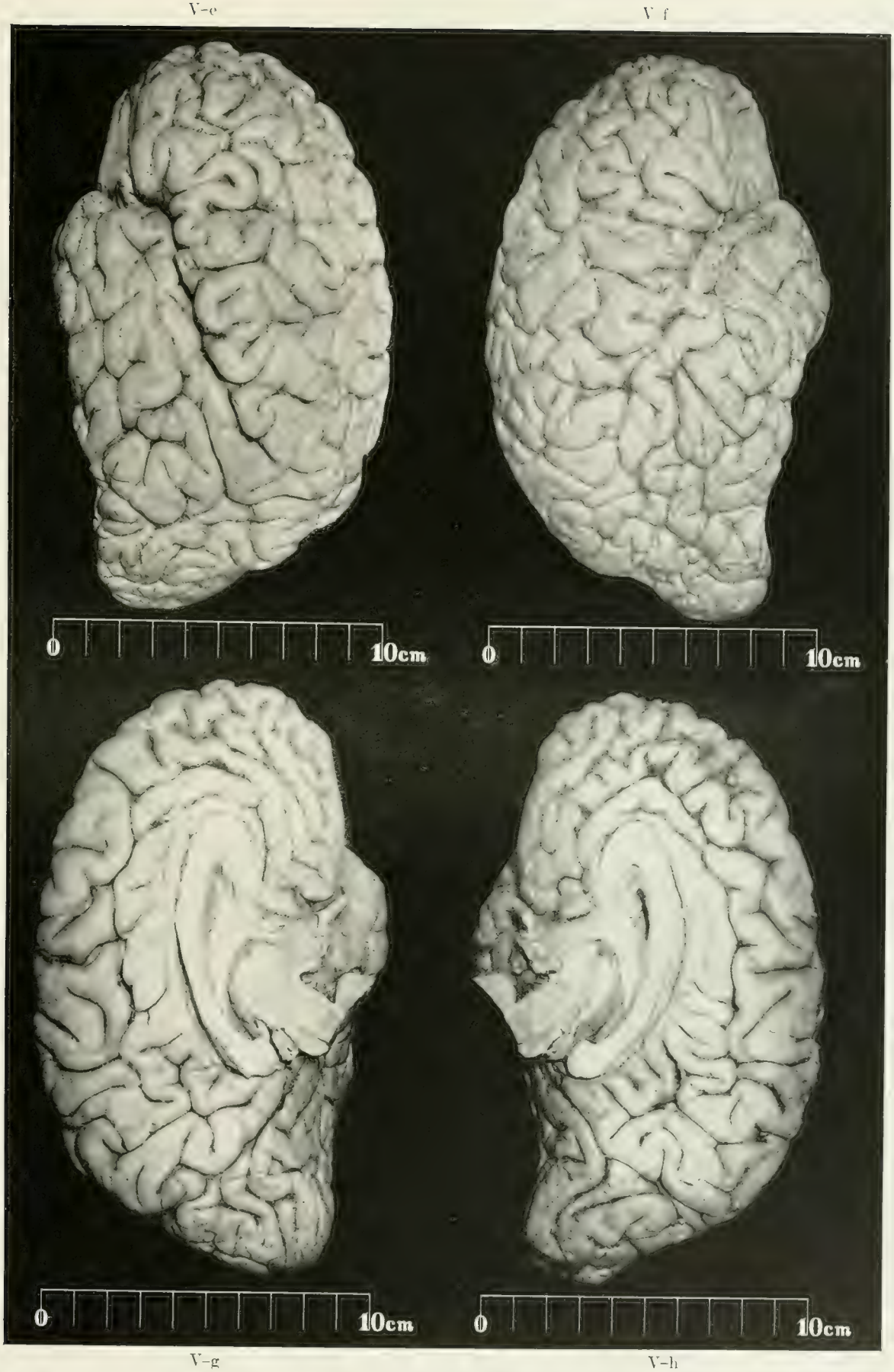
CASE IV — OLD ALMSHOUSE MORON



CASE IV — ALMSHOUSE MORON. NOTE HYDROCEPHALUS

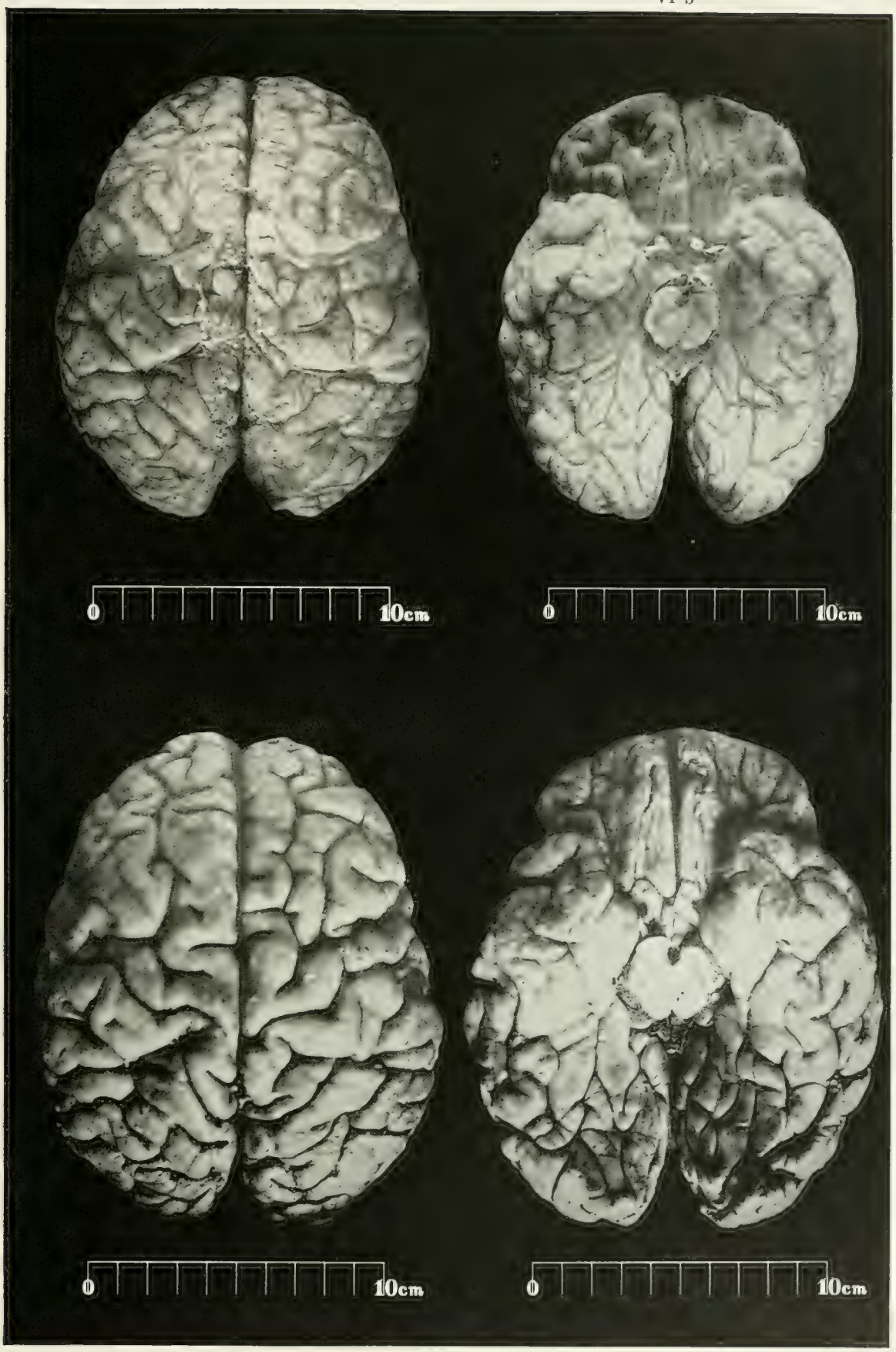


CASE V — MORON, TRUANT, DEMENTIA PRAECOX (?)



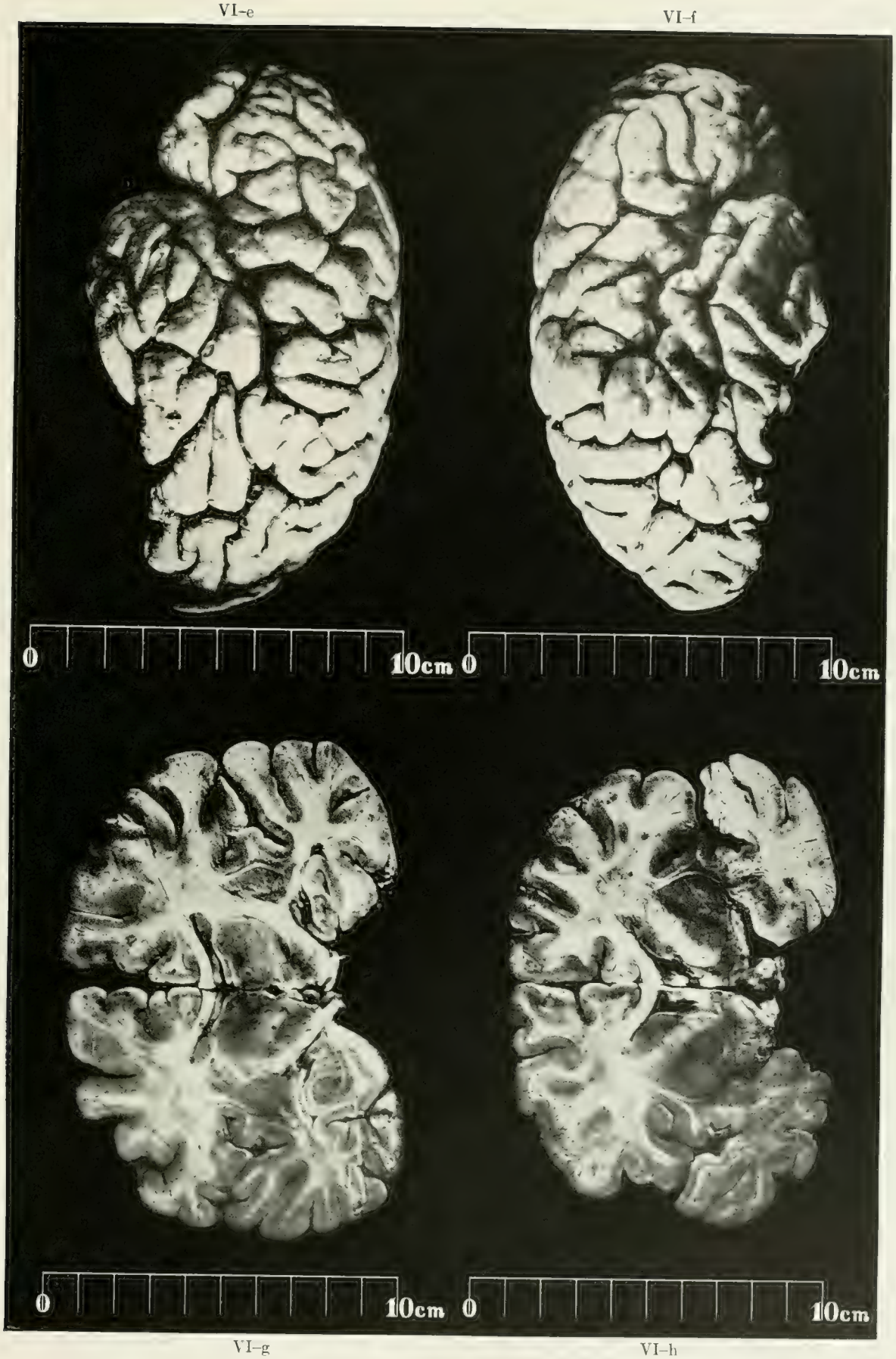
CASE V — MORON, TRUANT, DEMENTIA PRAECOX (?)

VI–a VI–b



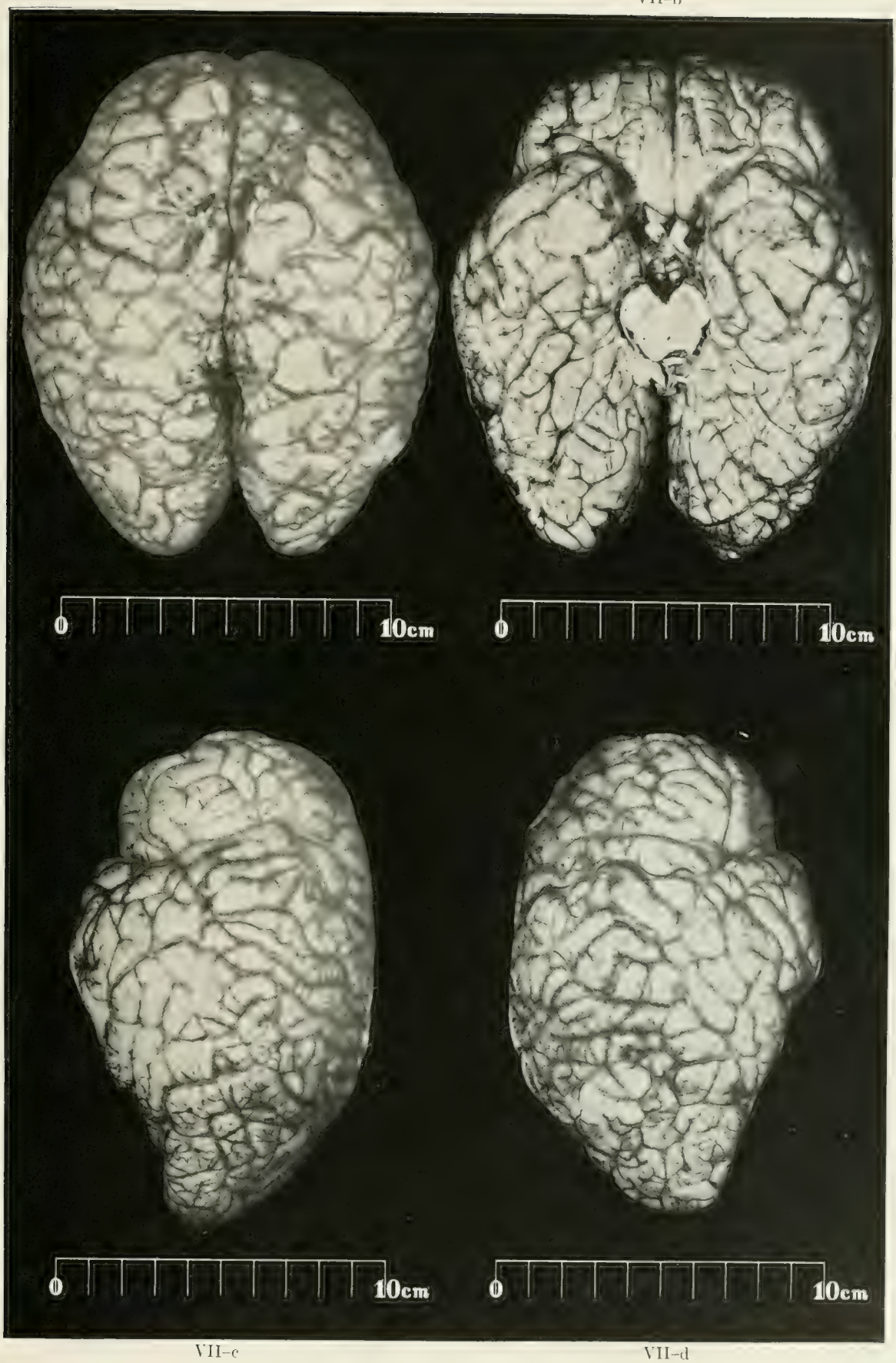
VI–c VI–d

CASE VI — IDIOT (APHASIA, VOCAL CORD ABSENT). SYPHILITIC (?)



CASE VI — IDIOT. SYPHILITIC(?) CORPUS CALLOSUM THIN

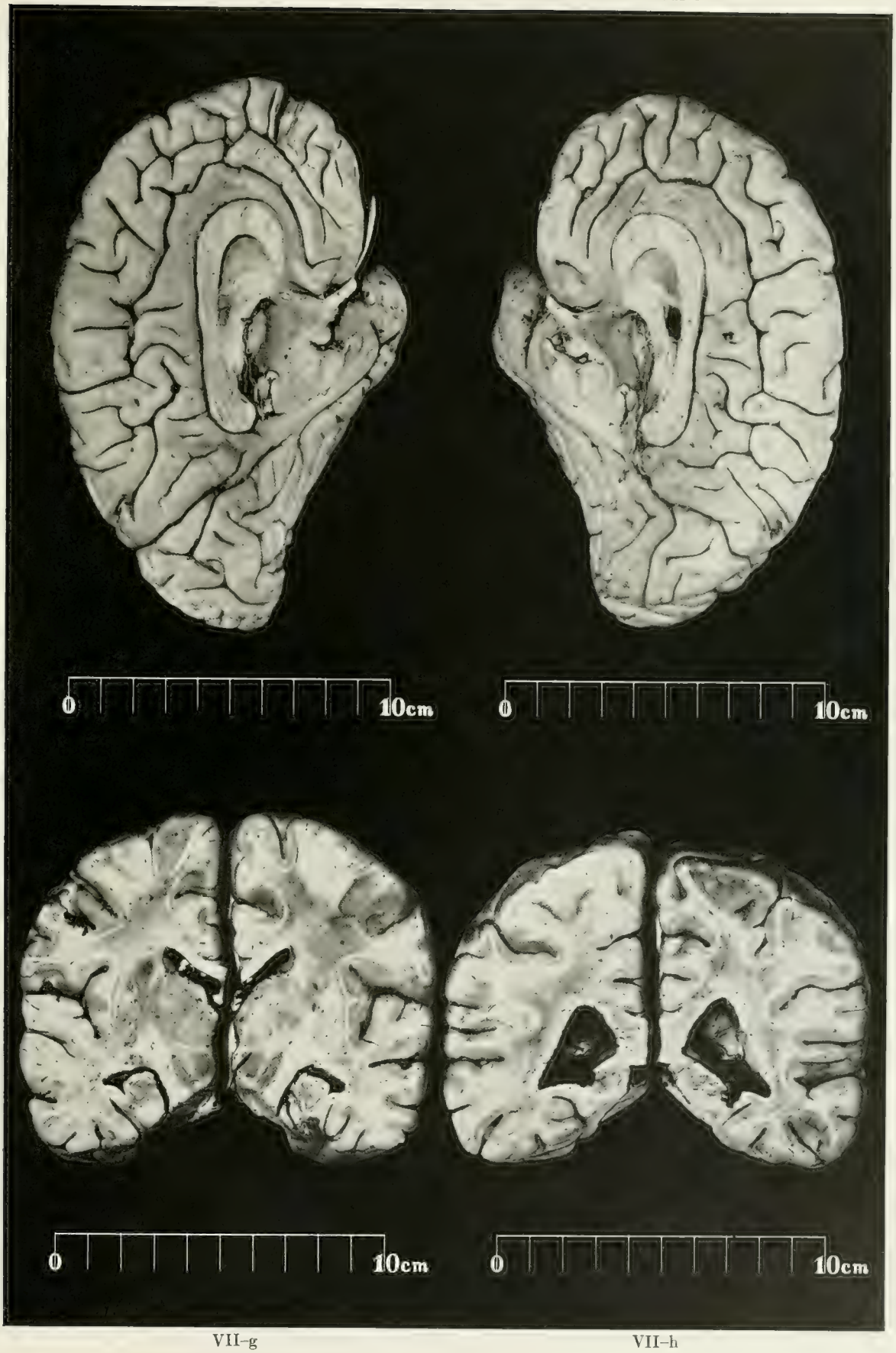
VII–a VII–b



VII–c VII–d

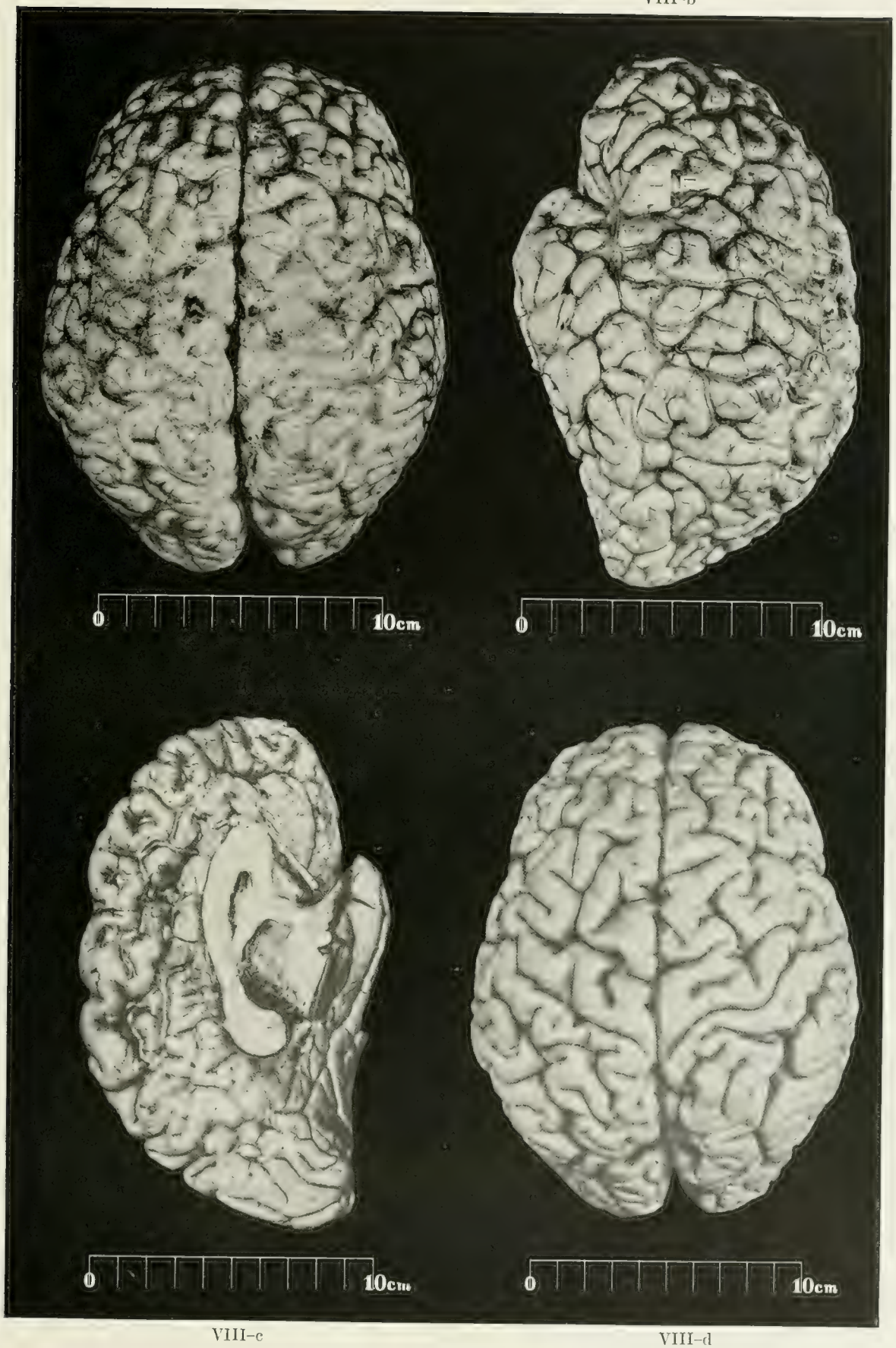
CASE VII — IMBECILE. SYPHILITIC (??)

VII–e VII–f



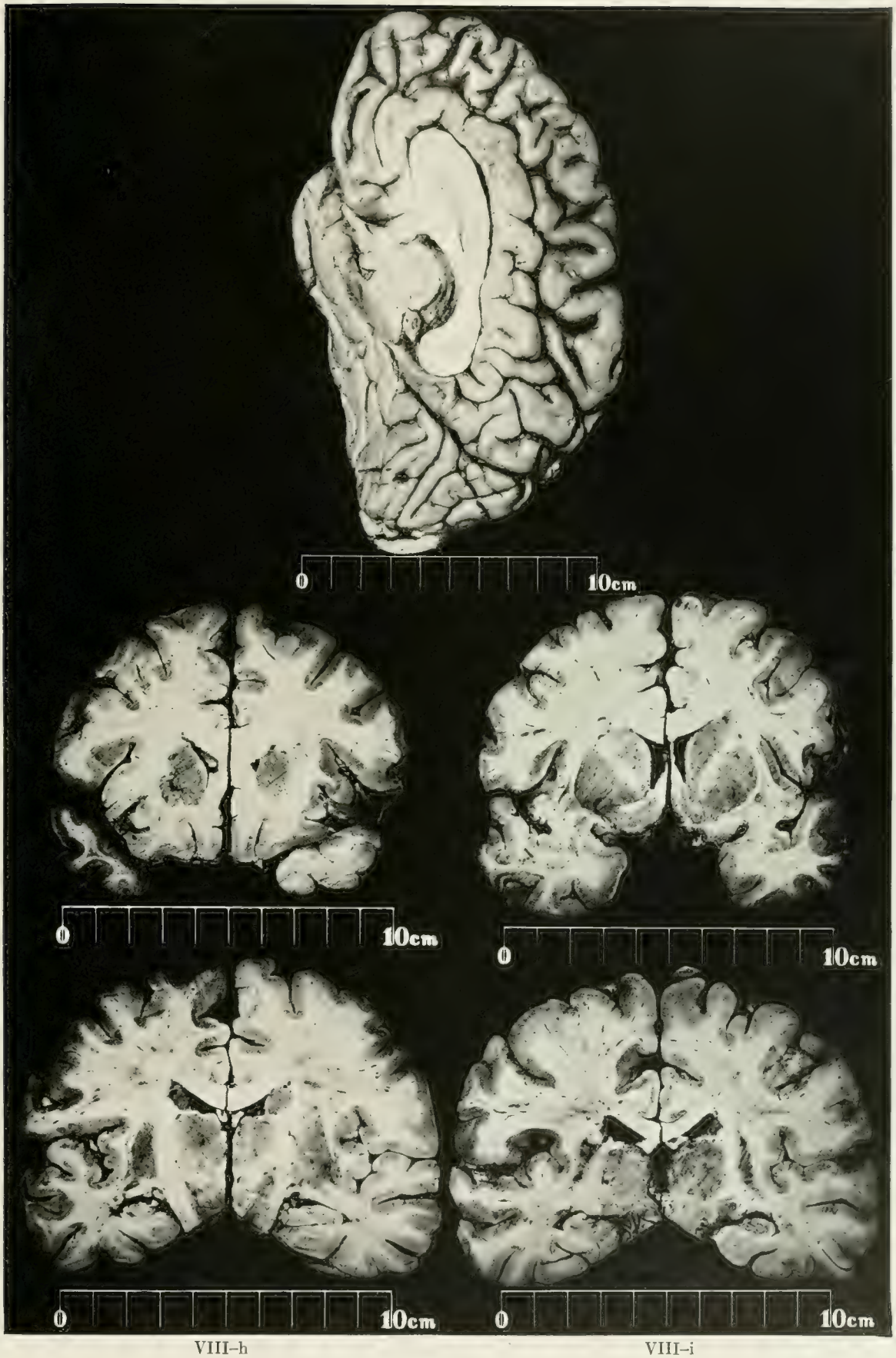
VII–g VII–h

CASE VII — IMBECILE. SYPHILITIC (?)



CASE VIII — MORON OR SUBNORMAL. EXECUTED MURDERER

VIII–e



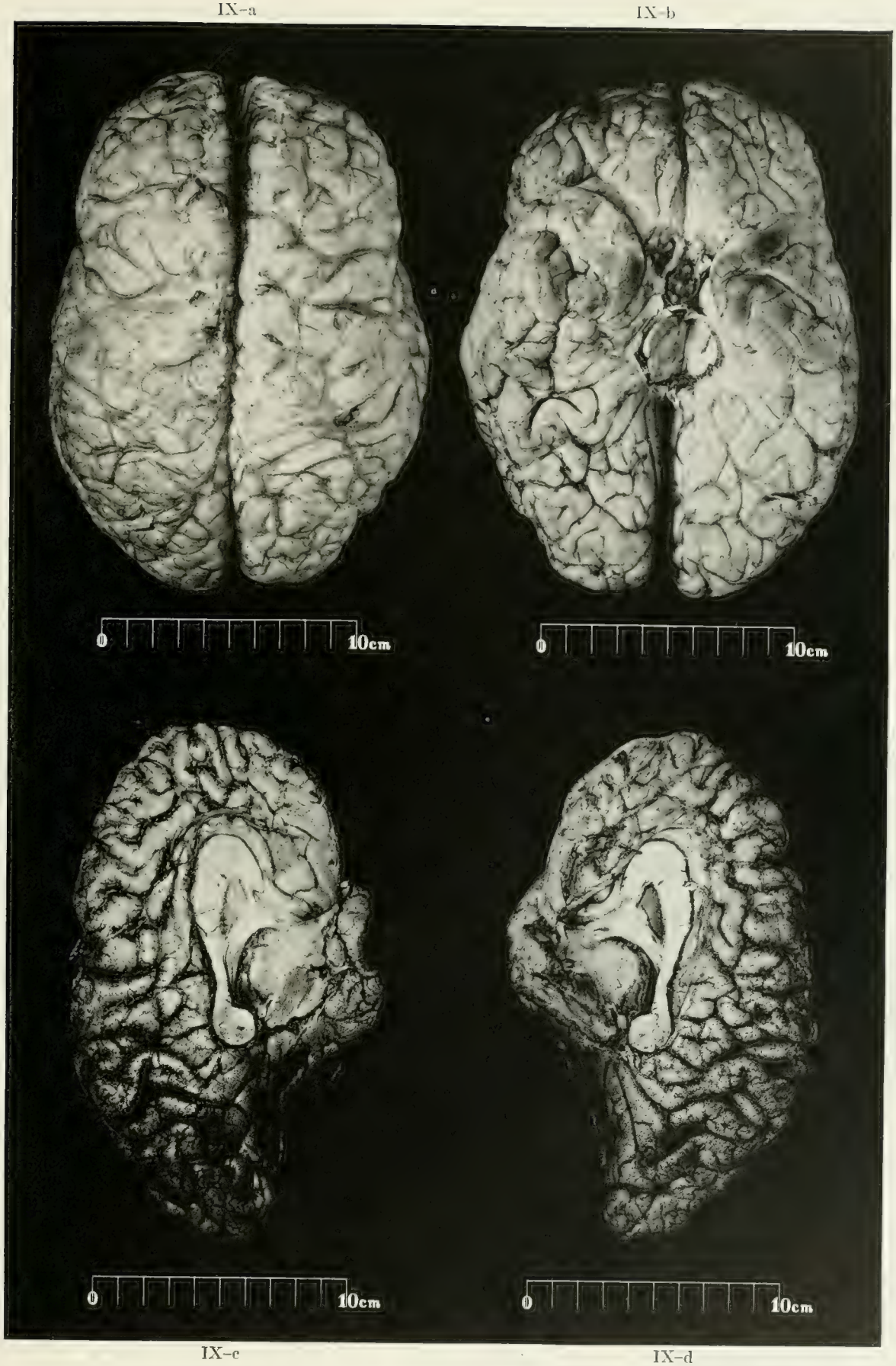
VIII–f

VIII–g

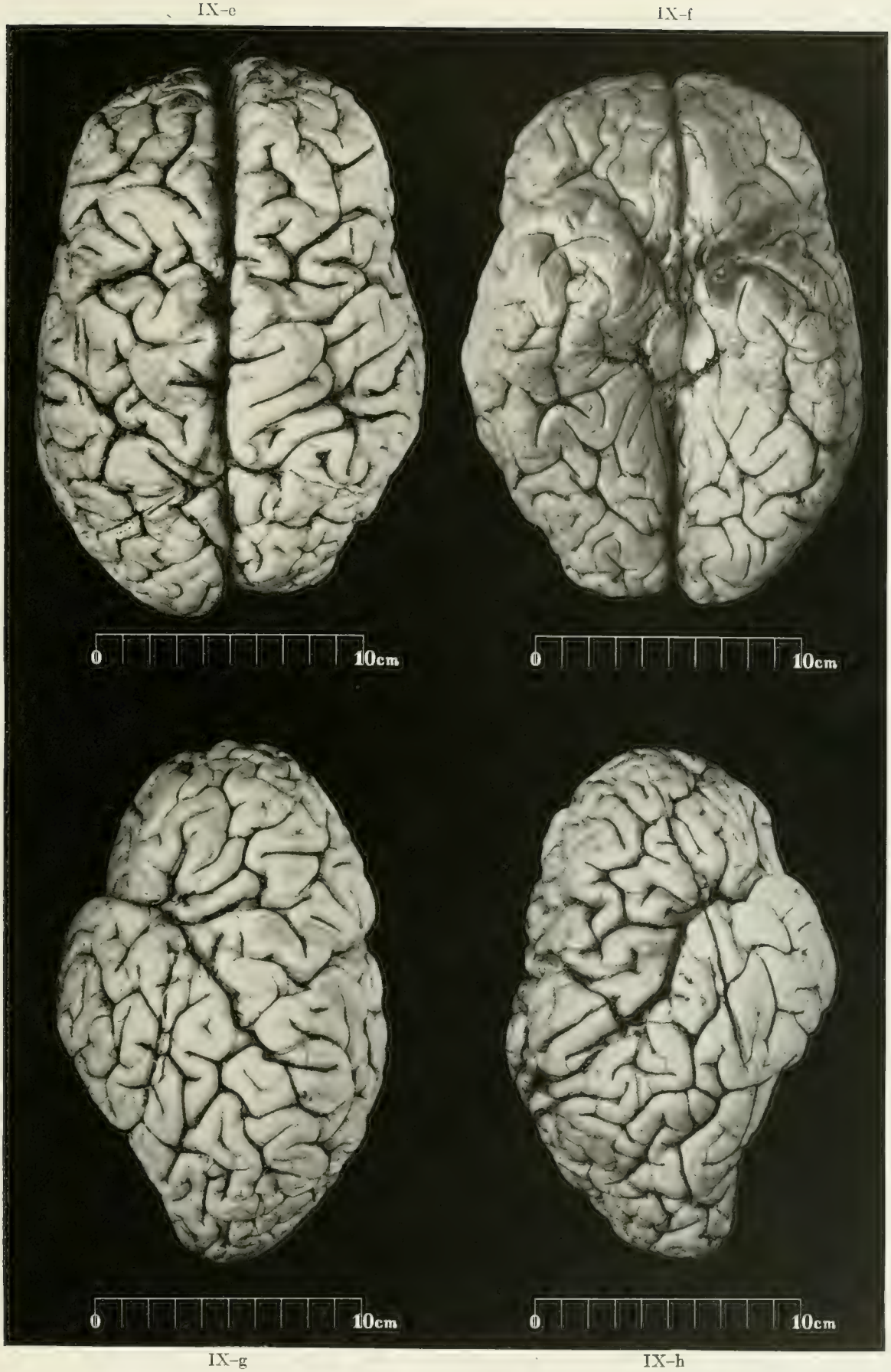
VIII–h

VIII–i

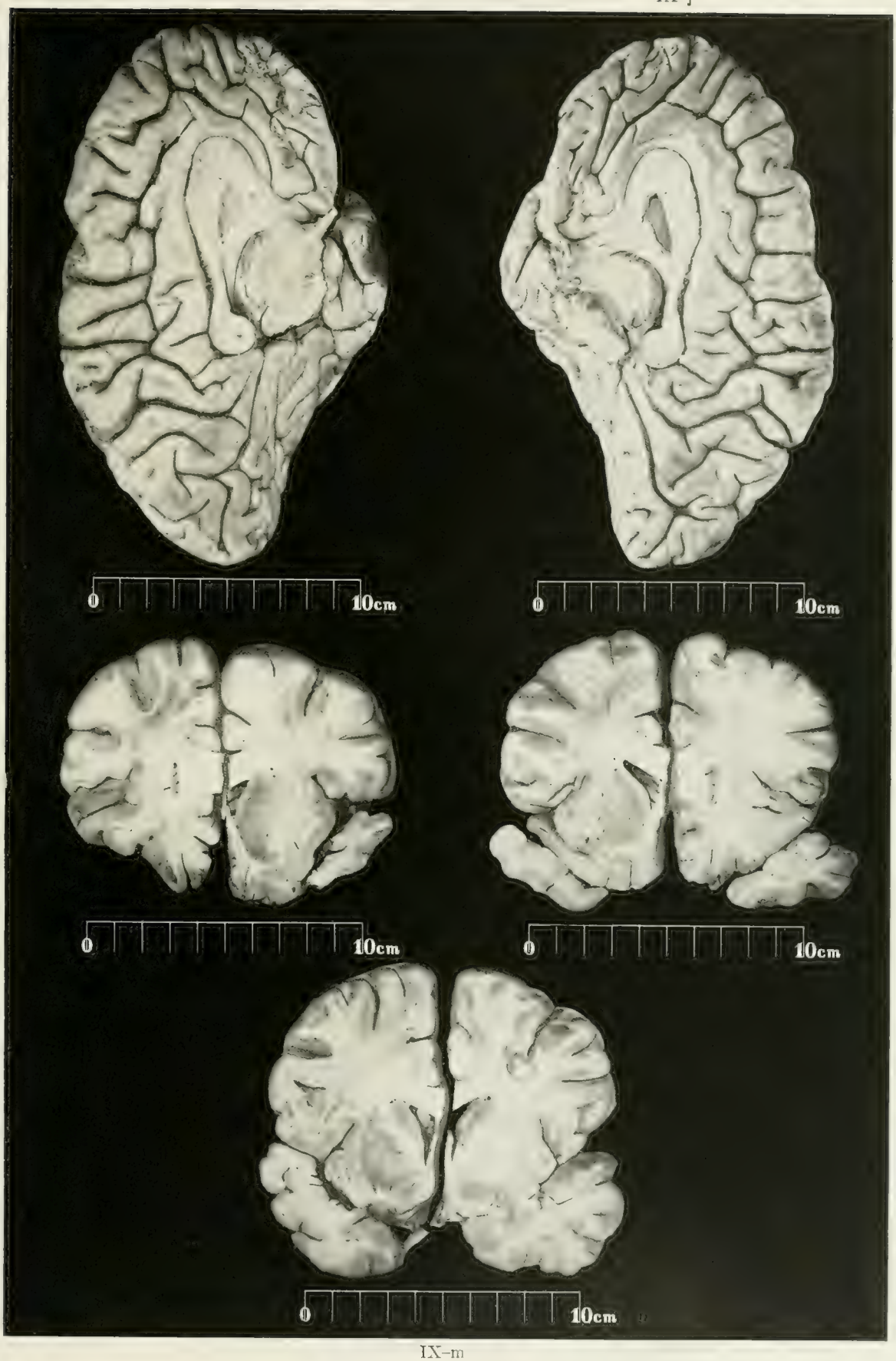
CASE VIII — MORON OR SUBNORMAL. EXECUTED MURDERER



CASE IX — "ABLE BODIED" IMBECILE. BRAIN WEIGHT 1622 GRAMS

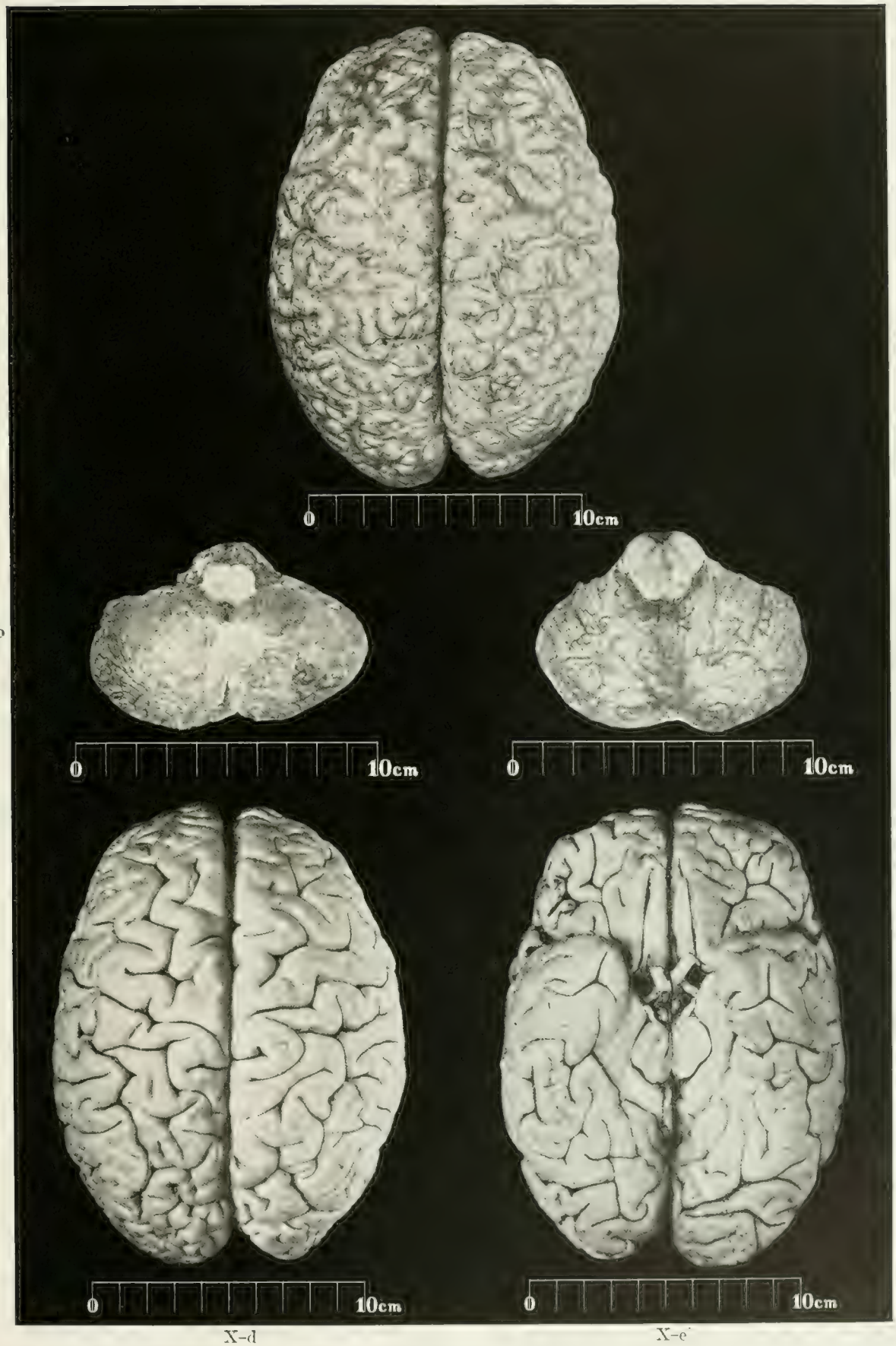


CASE IX — "ABLE BODIED" IMBECILE BRAIN WEIGHT 1622 GRAMS



CASE IX — "ABLE BODIED" IMBECILE. BRAIN WEIGHT 1622 GRAMS

X–a



X–b

X–c

X–d

X–e

CASE X — LOW IMBECILE (BINET 2.4)

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Vol. XIV, No. III. December, 1921.

WAVERLEY RESEARCHES IN THE PATHOLOGY OF THE FEEBLE-MINDED.

(Research Series, Cases XI to XX.)

WALTER E. FERNALD, M.D., A.M.

E. E. SOUTHARD, M.D., Sc.D.

MYRTELLE M. CANAVAN, M.D.

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(Research Series, Cases XI–XX.)

EDITED BY

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WITH THE COLLABORATION OF

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IV. Clinical, Anatomical, and Brief Histological Description of Ten Cases of Feeble-Mindedness, with plates (Waverley Research Series, Cases XI to XX) 131

E. E. Southard, Oscar J. Raeder and Annie E. Taft.

V. Correlations Between Mental Capacity and Brain Complexity in Twenty Cases of Feeble-Mindedness (Waverley Research Series, Cases I to XX). 187

E. E. Southard and Oscar J. Raeder.

IV.

CLINICAL, ANATOMICAL, AND BRIEF HISTOLOGICAL DESCRIPTION OF TEN CASES OF FEEBLE-MINDEDNESS, WITH THIRTY-TWO PLATES.

(WAVERLEY RESEARCH SERIES, CASES XI–XX.)

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With Thirty-Two Plates (Waverley Research Series XI–XX).

E. E. Southard, Oscar J. Raeder and Annie E. Taft.

The present paper and the one which follows it form the second instalment of the Waverley Researches in the Pathology of the Feeble-Minded. The first instalment published in May, 1918, dealt with Cases I to X, published in three papers.[1] The second instalment deals not only with the details of Cases XI to XX but has led to some general considerations concerning the entire series, Cases I to XX. It may be well to repeat that the editors have set a provisional terminus for the work at a series of fifty cases, the anatomical material for which is already largely in hand. The epicritical remarks which we intend to present by the way are after all nothing but *ballons d'essai.* Above all it must be insisted that the problem of the pathology of the feeble-minded is not a problem of the brain alone, but that all experience increasingly indicates that the problem of feeble-mindedness is in many ways a problem of pathology at large and in particular of that pathology of the endocrine glands which remain still so obscure.

We found our major brain problems in the first series (Cases I–X) in

a) the correlation of mental and cerebral measurements, and

b) the theoretically preventable group of feeble-mindednesses (e.g., syphilitic and post-poliomyelitic).

Both of these problems appear in stronger relief in the present series (Cases XI–XX) but the problem which we termed in 1918 *the* problem, namely, of *matching testable mind with measurable brain*, stands out so sharply that it has been thought best to place its discussion in a special paper following this.

[1] I. General Aspects of the Brain Anatomy in the Feeble-Minded, with Partial Bibliography. E. E. Southard.
II. Clinical, Anatomical, and Brief Histological Description of Ten Cases of Feeble-Mindedness, with 84 plates (Waverley Research Series, Cases I–X). E. E. Southard and Annie E. Taft.
III. Neuropathological Correlations with Clinical and Psychometric Findings in Feeble-Mindedness (Waverley Research Series, Cases I to X). E. E. Southard and Annie E. Taft.

We may refer to the preface of the former monograph for more general considerations, to Waverley Researches, article I, for a brief analysis of the general situation as regards brain anatomy in feeble-mindedness, to Waverley Researches, article II, *ad init.*, for the general plan of our descriptions and to Waverley Researches, article III, for certain general tabulations of the data in Cases I–X which we shall attempt to follow in our account of Cases XI–XX. The description of photographs is placed after article V, the plates being provided with Roman numerals to correspond with the cases shown.

For a brief characterization of each of the ten cases in the present group of the Waverley Research Series, reference may be made to the latter part of this paper. For more general considerations, reference is made to article V.

We now proceed to a condensed description of the findings in Cases XI–XX of the Waverley Research Series following the same plan of description employed in the preceding group. For convenience we offer a table which shows a number of facts about each case, chiefly of a catalogue nature.

TABLE VII.[1]

TABLE OF GENERAL AND CATALOGUE FEATURES.

CASES XI–XX.

Research Series number	Clinical Source number	Local Autopsy number	Harvard photographic number	Sex	Actual Age	Assigned Mental Age	Height last taken	Brain Weight, grams	Brief designation
XI	W. 441	S.B.I. 14.76	15.4	M	5 10/12	1.2	102	820	Hydrocephalus
XII	W. 2625	S.B.I. 15.48	15.18	F	20	3.4	148	2325	Hydrocephalus
XIII	W. 2677	S.B.I. 15.67	15.24	F	18	3.1	139	1160	Mongolian
XIV	W. 1910	S.B.I. 15.73	15.25	M	32	1.3	159	1205	Idiot
XV	W. 4753	S.B.I. 15.14	15.26	M	43	2.4	152	1070	Imbecile
XVI	W. 3137	S.B.I. 15.104	15.31	M	14	1.0	128	950	Macrogyria
XVII	W. 4203	S.B.I. 15.111	15.41	F	31	7.0	160	1275	Imbecile
XVIII	W. 4282	S.B.I. 15.125	15.48	M	9	1.0	115	1475	Idiot
XIX	W. 4300	S.B.I. 15.140	15.64	M	23	5.2	160	910	Mongolian
XX	W. 2208	S.B.I. 15.110	16.3	M	38	6.0	168	1390	Insane Imbecile

W. = Waverley (Massachusetts School for the Feeble-Minded).

S.B.I. = Massachusetts State Board of Insanity and refers to cases autopsied since the establishment of the Pathological Service of that Board, July 1, 1914.

As to the assigned mental ages, reference is made to the detail of the clinical findings.

The following brief comment on the items of our description already given in Volume I is repeated here for convenience of the reader. The items in general are:

a. Clinical Findings.

b. Autopsy Findings.

[1] The numbering of these tables is consecutive with the tables in the First Series of Waverley Researches, the last table of which was Table VI, pp. 118–119.

c. Special Description of Brain.
d. Partial Microscopic Description.
e. Anatomical and Histological Summary.

As to *a. Clinical Findings:* These have been arranged so far as possible to follow a scheme employed at the Massachusetts School for the Feeble-Minded and originated by Dr. W. E. Fernald. The headings are ten in number, as follows:

1. Physical Examination.
2. Family History.
3. Personal and Developmental History.
4. History of School Progress.
5. School Examinations.
6. Practical Knowledge.
7. Economic Efficiency.
8. Social History and Reactions.
9. Moral Reactions.
10. Psychological Tests.

Following the items thus arranged are notes, usually brief, concerning the institutional history, if any, of the patient.

As to *b. Autopsy Findings:* These are limited to the gross anatomical findings of the examiner as made on the autopsy table. Their results are more systematically given in table form in Article V.

As to *c. Special Description of Brain:* The data are founded upon examination, as a rule, subsequent to the autopsy and to the preservation of the brain, which has been in all cases in 10% formaldehyde solution, in many cases for relatively long periods, which are obvious from the dates included in the descriptions. As a rule, the special brain description has had the advantage of comparison of the brain specimen itself with the photographs, systematically taken, of the brain before and after stripping the pia mater. These descriptions are largely the product of Dr. Taft, who has personally stripped each brain of the pia mater, preserving the pia mater in certain cases where there was question of important lesion therein. The nomenclature is, as a rule, self-explanatory and follows largely the nomenclature of Quain's Anatomy.

As to *d. Partial Microscopic Examination:* It must be insisted that this is really but partial and has no pretensions to the completeness which the resources of a modern laboratory will eventually command. Nevertheless, we have resorted in each instance to total brain sections stained by the Weigert myelin sheath method in our estimates of the fibre

content of the brain. The resulting estimate is, as a rule, entirely qualitative. But it may be questioned whether it is possible at this time to make more than a qualitative estimate of fibre contents. The total brain sections stained by the Weigert method have been of value in the estimates of the depth of the corpus callosum, as well as for the purpose of discovering special periods of degeneration or faulty development of fibre systems.

We have, also, employed staining methods for the study of cortical architecture, employing as a rule cresyl-violet in place of thionin and methylene blue. This sharp nuclear stain has permitted us in most cases to make a profitable study of the cortical lamination, as well as to bring out the exudate about vessels where exudate is present. As will be emphasized in Article V, the existence of exudate in more cases than had been at first suspected is probably of importance from the genetic standpoint, since syphilis or some kindred chronic inflammatory condition may be suspected in cases with such exudate. Again, we have been able to observe rod cells in certain cases, which cells again tend to indicate a more progressive condition than has been considered typical in cases of feeble-mindedness. In suitable cases, we intend to make special topographical studies of cortical laminations. This we have in hand in chosen instances, and the resulting descriptions are intended to appear in later articles in this series. For the present, as will be evident from Article V, we have limited our microscopy to the question of exudate, rod cells, and the like, on the one hand, and to qualitative estimates of cortex lamination, fibre content, on the other.

As to *e. Anatomical and Histological Summary:* We have attempted to bring out the main structural points in each case, with, however, little or no attention to the total genetic picture presented by the case. This total genetic picture is reserved for Article V.

Further light upon the anatomical situation presented by each brain is offered in the description of the plates. The most inclusive view of each case from all available aspects: clinical, anatomical, histological, and genetic, together with points especially mentioned in the description of the plates, is given in Article V.

Synopsis of Findings of Case XI.

a) Clinical.[1]

1. Physical Examination.—J. K. Born February 10, 1909, and died November 29, 1914; admitted at 3 years, 9 months of age, November 16, 1912. Upon admission he was found to have a very large head, cranium broad and flattened in occipital region; was under-sized; at 5 years the patient

[1] The clinical findings have been arranged to follow a scheme employed at the Massachusetts School for the Feeble-Minded and originated by Dr. Walter E. Fernald, a general account of which has been given in Mental Hygiene, "Standardized Fields of Inquiry for Clinical Studies of Borderline Defectives," Vol. I, No. 2, April, 1917.

weighed 36¼ pounds and was 3 feet, 3 inches in height. Vision was defective, hearing normal; circulation was poor; extremities showed spastic paralysis, involving the muscles of the left arm, and of the right leg. The left face was paralyzed; there was toe-drop on the left side; patellar reflexes were increased on the right side. The upper lids of the eyes were kept habitually drawn up. Tonsils were enlarged; teeth poorly developed and nourished, and decayed to the gums. Parents of the patient were Irish-American.

2. **Family History.** Patient's father was 27 years of age and mother 22 years when patient was born; patient was the first child and mother's health was good during pregnancy. Mother a working-woman, supporting two other children who are stated to be normal; the mother did not know the whereabouts of the father as she had left him on account of confirmed drunkenness. The patient was visited by the mother at frequent intervals.

3. **Personal and Developmental History.** Patient had learned to say a few words, was helpless, could not walk or feed himself; untidy both day and night; there was a history of convulsions before admission but patient had none at the School. It is stated that patient's head began to enlarge when he was about 3 months old. There was a history of severe forceps injury and hemorrhage from the ears at birth. Spastic paralysis was stated to have developed after a period of severe convulsions. Patient was able to sing songs that he had heard once or twice, could remember an entire verse of a popular song such as " School Days "; patient understood what was said to him but if asked questions, was apt to repeat the question.

4. **History of School Progress.** Nil.

5. **School examinations.** Nil.

6. **Practical Knowledge.** Nil.

7. **Economic Efficiency.** Nil, except as stated under Physical Examination, (see above).

8. **Social History and Reactions.** Patient learned the names of all the children in the hospital; he spoke of one girl who had died, saying " she has gone to heaven."

9. **Moral Reactions.** Disposition happy, generally talking and singing. If moved or disturbed, patient seemed to feel discomfort and would cry.

10. **Psychological Tests.** 1.2 Binet examination performed June 22, 1914.

Waverley School History. Patient was taken acutely ill November 3, 1914, with high fever, pulse and respiration; temperature 102, later 100, and dropped to subnormal after 3 weeks. Death after 3 days of subnormal temperature; consciousness preserved up to one week before death; food taken up to last day. Occasional coughing; no opisthotonos or retraction of abdomen.

b) Autopsy.[1]

Body of a poorly developed child, fairly nourished, 102 cm. in length. Skin over arms wrinkled. Skin brawny over abdomen and extremities.

Measurements:	Circumference of chest at flare of ribs	50.7 cm.
	Circumference of chest at level of 3rd ribs	49.0 cm.
	Right arm at mid biceps	12.7 cm.
	Left " " " "	10.4 cm.
	Right wrist	9.9 cm.
	Left "	9.4 cm.
	Right leg mid thigh	20.5 cm.

[1] The autopsies in the present series were performed by Myrtelle M. Canavan, In Charge of the Pathological Division, Massachusetts State Psychiatric Institute.

Left leg mid thigh	19.4 cm.
Right knee	19.5 cm.
Left "	19.0 cm.
Right mid shin	13.5 cm.
Left " "	14.3 cm.
Length both feet plantar surface with toes extended	13.5 cm.
Neck measurement	22.8 cm.
Mento-bregmatic	10.9 cm.
Bimastoid	43.5 cm.
Mento-occipital	47.5 cm.
Circumference of head	66.7 cm.

The right leg is shorter than the left by 1.5 cm. The left arm is contractured, a "web" at angle of left elbow 2.5 cm. in depth. Thenar eminences flat. Penis rudimentary is 2.5 cm. in length. The scrotum is indicated by a few transverse wrinkles of skin, measures 3 × 3 cm.; color and consistency same as other portions of body. Dorsum of feet show some edema.

Weight of body 28 lbs.; head approximately 10–15 lbs.

Pupils — right 0.6 cm., left 0.4 cm. Eyeballs appear sunken.

Ventral Section.— Fat over abdomen 0.8 cm., over chest 0.4 cm. *Omentum* in a fern leaf pattern of fat distribution, is attached to descending colon. Spleen is adherent on external surface. *Appendix* has a mesentery of its own for entire length is 8.0 cm. in length. *Mesenteric lymph nodes* not enlarged except small ones in mesentery in coecal region. Diaphragm arches to 4th rib on right, 5th on left.

Thorax.— No free fluid in the thoracic cavities. Lungs free.

Heart.— Weight, 40 grams. 6 × 6 cm. Myocardium somewhat firm. Endocardium slightly edematous.

Measurements: T. V. 6.5 cm. P. V. 4.0 cm. L. V. 0.6 cm.
M. V. 6.5 cm. A. V. 4.5 cm. R. V. 0.2 cm.

Coronaries show no sclerosis.

Lungs.— Combined weight 225 grams.

Lower lobe of left lung is granular on its pleuric surface and dark red in color. It sinks in water. Section shows splenized appearance — some injection about bronchi which are thickened in their walls. There are definite collections of puriform material, stained smear from which shows no tubercle bacilli but polynuclear cells which show definite diplococci in pairs.

Organs of the Neck.— *Thymus* remains easily traced. *Thyroid* not examined.

Abdomen.— *Spleen.* 55 grams. Measures 10 × 5.5 × 1.0 cm. There are five foetal lobulations on external border. Pulp firm. Malpighian bodies numerous. Trabeculae not prominent.

Adrenals.— Small; negative in appearance.

Kidneys.— Weight 110 grams. 7.5 × 2 cm.

The left cortex measures 0.4 cm. Pyramids are white at apices. Pelvis much dilated and contains many gritty concretions near the apices in the calices. The ureter from this kidney is dilated and injected but not thickened. Right kidney same general description but the pelvis is not so injected, containing only one concretion. Some of the apices are entirely white.

Liver.— Weight, 340 grams. Measures 16 × 8 × 3.5 cm. Color brown-red. Gall bladder negative.

Pancreas.— Appears normal on section.

Gastro-Intestinal Tract.— *Stomach* dilated; no rugae present. Mucous surface looks glossy. Remainder of tract negative.

Genito-Urinary Tract.— Bladder contains a quantity of gritty brown mossy material but trigone and openings of ureters negative.

Prostate and testes not examined.

Retroperitoneal Tissues.— Aorta small and smooth. No lymph nodes seen near it. Thoracic duct and its receptaculum seen.

Head.— *Hair* yellow, somewhat dry and coarse but fairly abundant except over occipital region where it is worn off short. The scalp is oily and very thin but elastic.

Skull.— The color is irregularly blue with red points of injection. There are also white areas appearing between the sutures. On either side of the junction of the sagittal and coronal sutures are depressions and softenings of the cranium. The depression on the right appears to be an opening of the coronal suture externally to the limits of the fontanelle and measures 4×0.5–1.0. The one on the left is 2.5 cm. from the median line. Another depression which is soft allows the tip of the index finger to be placed in it and measures 3×0.8 cm. at one extremity and 1.5×1.3 cm. at another. This goes somewhat forward and outward on the suture angle and extends into the frontal bone. Surrounding these softened areas the calvarium is white in relief to the blue color and injection of the frontal portion. Following the sutures to the right are inserts of bone and white tracery surrounds these inserts; these supernumerary or Wormian bones measure 2.5×2.5 and 1.5×1 and 2.5×1.5 respectively and are situated in the coronal suture. No others seen in the sagittal and none in the lambdoidal suture.

The *calvarium* measures, *frontal*, *temporal* and *occipital* 0.2 cm. in thickness. Holding the calvarium to the light, the thickest portion is on either side of the longitudinal fissure and somewhat irregularly along the middle meningeal distribution. It is thinnest in the frontal portion at vertex above mentioned and in the superior occipital region. The left frontal eminence is more prominent than the right and the whole vertex on the left appears slightly higher than the right but anterior to the parietal bosses are slightly deeper depressions made evident by the bulging of the parietal bosses. The inequality of the parietal bosses not as marked as the frontal inequalities. Temporal muscles thin and undeveloped.

Dura is not adherent to the calvarium except slightly at vertex. The dura is thin, allowing brain convolutions to be readily seen through it. The dura is adherent to the pia in the right parietal region for a distance of 4×1.5 cm. along the anterior portion of the sylvian fissure and for the focal area 1×1.5 over the foot of the second frontal convolution, 4 cm. from the mid line on the right side.

Before the calvarium was removed, the brain was sawed into and a clear white fluid poured out to the extent of 84 fluid ounces (2380 cc.).

Pia is injected and the brain measures 20 cm. wide $\times$ 22 cm. long on the left hemisphere, approximately the same on the right. There is a suggestion of an occipital pole on the left but the right is a mere sac. The longitudinal sinus contains a little antemortem clot. The corpus callosum is present and is a translucent membrane 3 cm. in width at its posterior 3rd. There is direct communication from side to side of the lateral ventricles and the ventricles extend to the limits of the cortical covering of the brain.

Base of the brain. The olfactory bulbs are free but the posterior two-thirds of the olfactory tract are bound down firmly to the brain surface by a yellowish fibrinous exudate. This exudate is plainly visible in the circle of Willis and surrounds the 2nd, 3rd and 4th nerves, leaving the right 5th nerve free but involving the left 5th nerve. This exudate follows the basilar artery and the vertebrals and surrounds the medulla, closing entirely the 4th ventricle and covering the cerebellar notch, also appearing at the base of the cerebellum and following the small vessels over the hippocampal gyrus on the left but not on the right. This exudate which is massed at the base of the brain follows the Sylvian fissures, obliterating them. The cerebellum resumes a central position for the measurements at the base of the brain which are 22×18 cm. The cortex is greyish yellow in color. Pia injected. The thickness of the cortex is 0.1 over the right occipital region and over the right temporal portion anteriorly.

The left side of the brain appears to have more substance to it than the right, especially to be noted in the temporal lobe which has a palpable depth of 2.0 cm. against a palpable depth of 1.0 cm. on the right. This palpable depth on the right is thought to be due to extension of the tuberculous process at the base.

Cerebellum measures in greatest width 10.5, greatest anteroposterior diameter 5.5 and it is 2.5 cm. in thickness. With the exception of some shortening of the left lobe, the cerebellum has a fairly normal appearance. On palpation the left hemisphere is firmer than the right. The *posterior portion of the sella turcica* is membranous and the fossa itself is shallow. There is a small posterior nervous portion of the pituitary and the glandular portion is deep red.

Ear drums opaque.

Gasserian ganglia negative.

The optic disc of the right eye shows edema at its base. Vessels before division in central portion appear raised from the center. Disc of the left eye similar to right but circumference less.

Brain weight, (820 grams). (This brain still contains some of its fluid.)

Spinal Cord.— Underneath the dura the cord is bathed in yellow pus situated between the pia mater and the cord. In the middle of the thoracic portion there is a bloody mixture in the pus. The pia mater is lifted from the cord for a distance of one half cm.

Fluids from the (a) pericardial sac.
(b) free fluid from the ventricles,
(c) base of the brain,
(d) 3rd ventricle,
(e) spinal canal,
give reactions to the colloidal gold test.

A smear from the exudate at the base of the brain shows a marked display of large phagocytic cells which are in some instances enclosing other cells and in many cases enclosing brilliantly stained *tubercle bacilli.*

A smear from the pus in the lung substance is negative for tubercle bacilli but does show large numbers of polynuclear cells many of which contain diplococci.

Gold sol reactions were observed in fluids withdrawn post mortem and the fluid from the base of the brain showed a typical tuberculous reaction, 0 0 0 0 0 1 2 2 1 0.

The fluid from the ventricles was somewhat suggestive of tuberculosis (0 0 X/2 2 2 1 0 0 2?).

The fluid from about the spinal cord would be interpreted as either septic or tuberculous 1 1 1 1 1 1 1 2 3 3).

Anatomical Diagnosis (General Appearance and Anomalies).

Poor development.
Poor nutrition.
Brawny skin.
Inequalities of measurements of limbs with contracture of left arm and shortening of right leg.
Penis undeveloped.
Head hydrocephalic with anterior fontanelle not completely closed and with Wormian bones.
Calvarium thin and of unequal thickness.
Oily scalp.
Unequal pupils.

Acute lesions.

Bronchopneumonia (not proved tuberculous).

Tuberculous meningoencephalitis with hydrocephalous injection of pia mater and lesions most marked in the basilar region.

Retinal inflammation.

Tuberculous spinal meningitis.

Brain weight 820 grams

Chronic lesions.

Renal stone with hydroureter.

c) and d) Special Description of Brain and Microscopic Examination.

The measurements of the brain are given under the autopsy description.

Microscopic sections were made from right hemisphere as follows:

Section from the parolfactory region shows very well the exudate on the base of the brain. This surrounds the vessels of the adherent pia and is made up of lymphoid cells and large phagocytic mononuclear cells and fibrin,— a similar exudate surrounds the vessels in the overlying brain tissue. The endothelial layer of the pial vessels is swollen, and in some places lifted from the underlying layer,— among many others the cells have infiltrated the muscular layers of the vessel wall. There is extreme proliferation of all forms of fibre-bearing cells, many of which have considerable protoplasm. There are foci of cell infiltration of the exudative type in the subependymal tissue where there is also much glia cell and fibre increase. The ependymal cells appear to be proliferating.

The wall of the hemisphere in the calcarine region was in places only 6.0 mm. in thickness. The pia mater over this region was thin and closely adherent to the cortical substance. It was impossible here to study the microscopic conditions of the brain without reference to acute lesions. The characteristic lamination of the calcarine cortex was distinct and the solitary cells of Meynert were in evidence. There is, however, a certain degree of cell scarcity. Most of the nerve cells have a shrunken appearance so that the nuclei appear large in proportion to the cell bodies. The apical processes of the nerve cells are often wavy. There is a general tendency to chromatolysis, very possibly due to the acute lesions in the brain. Upon the ependymal surface of the section there is a marked cellular gliosis not unlike the cellular gliosis described above for the parolfactory region. The vessels of the white substance are surrounded with exudative cells and along the capillaries there is a good deal of glial " beading."

The frontal region, for example, in the superior frontal gyrus is still thinner and in places no thicker than 3 mm.; here the thinning out of cells is everywhere well marked but more notable in the outer layers. There is some sort of glial reaction as described elsewhere. The perivascular reaction is slight.

Sections from the inferior parietal area show a more moderate thinning out of the cells and the superior parietal region in general resembles the inferior parietal. There is a marked perivascular exudate of the vessels near the ventricular wall.

A section from the angular gyrus presents the same appearance as those of the inferior parietal area.

Concerning the sections in general, there were observed many small collections of cells in the white substance beneath the ependyma. These cells were chiefly large mononuclear cells of the endothelioid type. Occasionally these cell collections had grown large enough to make a "granule" or miliary tubercle on the ependymal surface. These groups of cells were usually found to stand in close relation with a blood vessel.

The ventricles are enormously dilated so that a shell of grey and white matter surrounding at top and sides measures less than 2 mm. to 7.0 mm. and in other regions from 3 mm. to 1.5 cm. The brain matter surrounding the inferior horn measures as low as 0.5 mm. to 2.5 mm. on the right side, and from 1 mm. to 6 or 7 mm. on the left, so that the process of hydrocephalic dilatation is slightly greater on the right. (See plates for gross sections.)

The white matter is pressed out against the grey so that in areas of extreme stretching it consists of only a thin band underlying the cortex. The flattened caudate nucleus is distinctly separated from the lenticular nucleus, which is also flattened by a thick internal capsule in which the fibres are closely crowded upon each other. The external capsule is plainly demarcated, and the cornu ammonis is relatively intact though considerably flattened and reduced in size. There is no other evidence of fibre degeneration.

Cerebellum.— The fourth ventricle is extensively dilated in a section through superior peduncle,

1.7 cm. to 2.5 cm. There appears to be a slight thinning out of the medulla. The neighboring tissues are slightly distorted by the dilatation of the fourth ventricle.

The bulb and cord besides showing the exudative meningitis more marked on the posterior surface (with cell types like those seen elsewhere) also show evidence of a more chronic lesion, namely, a " greying-out " of one of the pyramids and of one lateral column (pyramidal tract). The sections of the cord show an appropriate unilateral reduction in the fibre bundles making up the pyramidal tract. This lesion corresponds with the inequalities in thickness of brain substance noted in the autopsy description (left side of brain, e. g., in temporal region 2.0 cm. thick as against 1.0 cm. on the right).

e) Anatomical and Histological Summary

There is exudate on the base of the brain. This surrounds the vessels of the adherent pia and is made up of lymphoid cells and large phagocytic mononuclear cells and fibrin,— a similar exudate surrounds the vessels in the overlying brain tissue. The endothelial layer of the pial vessels is swollen, and in some places lifted from the underlying layer,— among many others the cells have infiltrated the muscular layers of the vessel walls. There is extreme proliferation of all forms of fibre-bearing cells, many of which have considerable protoplasm. There are foci of cell infiltration of the exudative type in the subependymal tissue where there is also much glia cell and fibre increase. The ependymal cells appear to be proliferating.

The brain of this case would have been a typical hydrocephalic brain had it not been for the complication of tuberculous meningoencephalitis. The total duration of acute disease in this case was less than four weeks, yet large collections of mononuclear cells were found in various parts of the brain, particularly in the region below the lining of the ventricles. The neuropathologist is continually astonished at the long standing look of many of these lesions despite the clinical evidence of their comparatively recent origin.

The brain photographs demonstrate more effectively than description the general anatomical situation in this case of hydrocephalus. The brain substance though in places only 3.0 mm. deep, nevertheless showed very definite stratification resembling that of the normal brain. The absolute number of cells was probably diminished and in places there was evidence of both an absolute and relative diminution in a number of cells. The acute tuberculous lesions superimposed upon the brain had given rise to various cell changes such as very general display of chromatolysis which makes it difficult or impossible to determine whether the nerve cells were to any degree hypoplastic.

Very special studies of the topography in hydrocephalus have been made by S. T. Orton in his case of hydrocephalus published in 1908. Our special interest in this study is to compare in general the findings in a case like Case XI, having a mental age of 1.2 Binet with the findings in such a case as Case XII, having a mental age of 3.4 Binet. The relations between these cases are discussed more fully in Article V.

Synopsis of Findings, Case XII.

a) Clinical.

1. Physical Examination. A.B., female, born August 25, 1895, and died April 22, 1915. Patient admitted at 9 years, 6 months, February 23, 1905. Upon admission, head was found to be abnormal, with a protrusion of forehead, abnormal width between the ears and height above the ears. Physical examination in 1914 showed height 4′ 8″, weight 99¾ pounds; good nutrition, right side of chest prominent, left sunken; thin, coarse hair; exaggeration of all reflexes, rolling of head; ankle clonus of right

side; foot-drop and wrist-drop. Scars of bridge of nose and lip; circumference of cranium 25 inches, cephalic index 84.39. Opaque left cornea; patient is blind, except that darkness can be distinguished from daylight.

2. **Family History.** Parents of old American stock, father was 29 years of age and mother was 28 when patient was born. There had been two children before patient and two later. The mother's health was good during pregnancy, but she had been subject to sorrow on account of death of patient's grandmother. It is stated that one other child is lame.

3. **Personal and Developmental History.** First peculiarity was noted in the month after birth when the abnormal size of the head began to be apparent. At about 5 years, patient began to have convulsions at intervals of a month. The convulsive tendency lasted a year; there were then no convulsions until admission of the patient.

Patient had become active and interested in things about her. Her hearing was excellent and she was passionately fond of music, playing the piano by ear. Her command of language is stated to have been perfect; gait staggering and there was echolalia.

4. **History of School Progress.** Nil.

5. **School Examinations.** Nil.

6 and 7. **Practical Knowledge and Economic Efficiency.**— Before patient became blind, she was fond of music and of playing games.

8. **Social History and Reactions.** Was fond of singing and often tried to sing in class.

9. **Moral Reactions.**— At first of rather quiet disposition, became somewhat erratic along with her mental deterioration. This deterioration was more pronounced at or about the convulsive periods.

10. **Psychological Tests.** 3.4 Binet performed June 22, 1914.

Waverley School History — After admission, patient developed convulsions at frequent intervals. She became gradually more blind and almost absolutely blind during the last year. Patient grew progressively weaker and more emaciated and after the attacks of convulsions would remain in a stupor for several days. The patient was a lover of music and played on the piano. She wound spools slowly and unevenly, was able to button and unbutton the button strips. She required aid in sewing and in weaving; was unable to darn but was able to braid. Patient tried hard to do work but it seemed that her eyesight interfered with her capacity. She was able to successfully make beds in the bed-making class and to carry out ordinary hand work.

b) Autopsy

The section was made 12 hours postmortem.

Body of a slenderly built, poorly nourished, white female 148 cm. in length.

Circumference of head, 61.5 cm.
Chin to glabella, 13 cm.
Glabella to occiput, 33 cm.
Interparietal, 25 cm.
Mastoid to mastoid, 37 cm.
Between zygomatic processes, 14 cm.
From angle of jaw to angle of jaw, 19 cm.
Ears, length, 5 cm., breadth, 3 cm.
Circumference of neck, 25 cm.
Arms, mid-biceps, 15 cm.
Wrists, 11.4 cm.
Right leg, mid-thigh, 27.5 cm.
Right mid-shin, 18.5 cm.
Right ankle, 15 cm.
Left leg, mid-thigh, 28.5 cm.
Left mid-shin, 18.6 cm.
Ankle, 15.5 cm.
Plantar surface right foot to tip of toe, 18 cm.
Plantar surface of left foot to tip of toe, 20 cm.
Circumference of thorax, 63 cm.
Circumference at crest of ilium, 63 cm.
Length of sternum, 13 cm.

Right side of chest very prominent; *left* somewhat sunken below the 8th rib.

Skin brownish in color, especially face and legs. There is a *bruise* over the left shin, 9 × 5 cm., over acromion processes, 3 × 2 cm. *Thenar eminences* are flat. *Hypothenar* eminences not developed.

There is a straight line from the wrist to the base of the little finger.

Pupils: right 0.2 cm., left not measurable.

Ventral Section.— *Fat* over *abdomen* 0.7 cm., over *chest* 0.5 cm., orange yellow in color. *Omentum* scanty in fat. *Stomach* 3 cm., transverse colon, 9 cm. below ensiform. *Liver* above costal margin.

No free fluid in peritoneal cavity. *Appendix* measures 10 cm., points toward liver. Spleen free. Diaphragm arches to the 5th rib on each side. Lymph nodes not enlarged.

Thorax.— Lungs overlap in median line. No free fluid in thoracic cavity.

Heart.— Weight, 198 grams. Measures 9 × 9 cm. Epicardial fat yellow and abundant. Endocardium of left ventricle markedly thickened. (This endocardium might well have been seen in a person 70 years of age.) *Heart muscle* firm, pinkish grey in color. Definite *hemorrhages* under endocardium in left ventricle.

Measurements: T. V. 9.0 cm. P. V. 5.5 cm. L. V. 1.0 cm.
M. V. 9.0 cm. A. V. 5.5 cm. R. V. 0.3 cm.

There is thickening of the free edges of the tricuspid valve and *inequality* of *aortic leaflets.* One measures 1.5 cm., the other 2 cm. in diameter at base. The coronaries show some thickening.

Organs of the Neck.— Thyroid not notable. No thymus gland seen.

Lungs.— Weight 210 grams, left. Weight of right, 269 grams. Nothing of note on section of lungs.

Abdomen.— *Spleen.* Weight 75 grams. Four fetal lobulations. Capsule thickened and wrinkled. Pulp firm. Trabeculae increased. No Malpighian bodies.

Adrenals.— Not notable.

Kidneys.— Weight not taken. Measure 9.5 × 4 cm. Capsule not markedly thickened. Strips easily. Cortex measures 0.4 cm. Color greyish brown. Slight injection. Apices of pyramids show white streaks. Same description for other kidney except pelvis is bathed in purulent fluid.

Liver.— Weight 875 grams. Measures 21 × 15 × 5 cm. Inferior edges blunt. Color red. Unusual amount of blood on section. No gallstones in gall bladder.

Pancreas.— Not notable.

Gastro-Intestinal Tract.— Not remarkable.

Genito-Urinary Tract.— Bladder negative. Vagina small; cervix 1 cm. in length and 1 cm. in breadth. Os extends laterally. *Ovaries* unequal in size; one measures 3 × 1.8 cm., the other 2 × 1 cm. The other ovary contains cysts.

The entire length of the uterus is 4 cm., width 2.5 cm.

Retroperitoneal Tissues. — Show no enlarged lymph nodes near the aorta. The aorta is small in calibre. Shows no sclerosis.

Head.— Hair dry; scalp thin. Inner surface of scalp shows two areas of hemorrhage 5 × 5 cm. and 2 × 3 cm. over right frontoparietal region.

Calvarium appears unequal, the right half being larger than the left. There is one Wormian bone in the lambdoidal suture on the right.

Calvarium measures 0.3 cm. in thickness.

The *dura mater* is adherent at a point near the base of the second frontal convolution on the right and over the left temporoparietal region on the left. Considerable force necessary to free it in these portions.

The brain is *remarkably dilated* in the frontal portions and in the occipital portions, a mere shell of grey matter separating the ventricles from the dura.

Over the *temporal* and *parietal regions* the substance of the brain is greater. The brain is removed without losing fluid. (It would be better to make a definite cut in the under surface of brain and remove the fluid in that way before removing brain.)

The base of the brain: The space around the optic nerves is bulging and bluish in color from its thinness and the amount of fluid which presses upon it.

The *optic nerves* are mere threads. The *olfactory bulbs*, degenerated.

The *basal vessels* show nothing especially.

The temporal tips are remarkably parchment-like and thin and the hippocampal gyrus near superior cuneiform lobe shows a triangle of whitish tissue like that described in the second right frontal. (Congenital absence of cortical material?).

The *cerebellum* and *pons* appear somewhat small but otherwise no abnormalities.

Base of skull shows flattening of the orbital plate of the frontal bone. The petrous portion of the temporal bone shows thickening but points of pressure thinning. The pituitary body is small and is encroached upon by the downward pressure of the clinoid processes.

The Gasserian ganglions were negative.

Optic nerve discs show ? of choking.

The brain and its fluid weighed 2325 *grams.* Tigges' formula 8×148: 1184 grams. *Gain in weight,* 1141 *grams.*

Cord negative.

Anatomical Diagnoses, General Appearance and Anomalies.

Poor nutrition.

Maldevelopment of thenar and hypothenar eminences.

Prominence of one side of the chest.

Inequality of aortic leaflets.

Infantile uterus.

Head.— Hydrocephalus with small pituitary, Wormian bones, calvarium thin and asymmetrically developed, atrophy of optic nerves and olfactory tracts, choked discs, pressure effects upon basal structures of the brain and focal adhesions of dura mater.

Acute Lesions.

Pyelonephritis.
Hemorrhagic myocarditis.
Hemorrhage of scalp.
Bruise of left shin.

Chronic Lesions.

(See also under hydrocephalus above.)

Coronary sclerosis.
Chronic fibrous endocarditis (ventricular walls and tricuspid valve).
Chronic perisplenitis.
Chronic interstitial nephritis.
Cystic ovary.
Opacity of one cornea.

c) Special Anatomical Description of Brain.

The head measurements are given in the autopsy description. The brain was markedly hydrocephalic. There were adhesions of the pia mater between the mesial surfaces about the knee of the corpus callosum. There was also a slight chronic meningitis over the base of the brain, over the orbital surfaces and about the Sylvian fissures.

The convolutional pattern is much obscured by the flattening of the hemispheres. The right hemisphere is more markedly thinned anteriorly whereas the left hemisphere is thinned out somewhat more posteriorly. The floor of the third ventricle has undergone a thinning out under pressure which has also involved the optic nerves to a remarkable degree. The optic nerves are completely flattened over the

commissure but the left nerve emerges sufficiently intact to be recognized whereas upon the right side an optic nerve can hardly be identified.

The aqueduct of Sylvius has undergone complete obliteration. The septum lucidum is made up only of a fine network of fibres. The corpus callosum itself is only very moderately thinned being as a rule less than 1 mm. thick.

The ependyma of the third ventricle is granular as also of the fourth ventricle. In the floor of the left hemisphere is a cavity formation 2 × 0.5 cm. in diameter by 1 cm. in depth. The basal vessels are small and elastic and exhibit no gross lesions.

The pia mater over the base of the cerebellum is thickened and milky. There is no asymmetry of the cerebellum which appears to show no noticeable changes in the gross.

d) Microscopic Examination.

An abstract of the most important findings yet made is as follows. The identification of areas has to be histological rather than topographical inasmuch as the hydrocephalic distension of the brain has caused wide translocation of areas reminding one of the findings in S. T. Orton's description of the pathological anatomy of a hydrocephalic brain.

Very important from the standpoint of etiology is the discovery in various areas of infiltrative cells, small and large, mononuclear cells sometimes suggesting plasma cells. This finding indicates chronic inflammation of the sort found in syphilitic disease. The findings are similar to those in Case XI. It is possible, nay probable, that both cases are syphilitic in origin—a hypothesis that may be raised for most instances of early hydrocephalus.

Cellular and fibrillar gliosis is found in the subpial layers of numerous areas. In one area (in the posterior two-thirds of the right post central gyrus) there was a focus of gliosis extending from white matter to periphery large enough to be seen in the gross. The white matter shows a general increase of neuroglia cells of a slightly irregular arrangement. The gliosis of the subpial layer is characteristically more severe at the bottoms of the sulci than upon the crowns of the gyri.

The diminution in the number of the nerve cells is less considerable than might have been expected although distinctly in evidence in a variety of loci. Very interesting is the existence of several types of gliosis ranging from fibrillar to cellular; and some of the neuroglia cells have the " active " appearance characterized by large cell bodies with distinct protoplasmic processes. Various sections taken through the ependymal layer show a characteristically marked gliosis going somewhat deeply under the layer.

The blood vessels are for the most part negative though an occasional section exhibits a focal thickening of the intima in a small vessel.

No attempt was made to make a complete histological study of this case although eighteen areas were microscopically studied and some endeavor made to count nerve cells. Occasional areas (for instance the left superior parietal) show small foci in the cortex entirely replaced by neuroglia with colloid deposits. The gliosis here was of a cellular nature showing all forms of neuroglia cells.

With respect to degenerative changes and the disposal of cell detritus there were in a few areas only a good many heavily pigmented phagocytic cells about vessels in the white matter; but other cells failed to show any pigmented phagocytes whatever.

Some areas notably the left angular gyrus (right superior frontal, etc.) show a gliosis of increasing severity as one approaches the ventricular surface — a finding consistent either with greater local pressure exerted upon the interior of the tissue or with the hypothesis of toxic effects from the ventricular fluid.

With respect to the qualities of nerve cells themselves, it was remarkable that some of the largest nerve cells retain a complete equipment of Nissl bodies but most of the large cells had a characteristically dusty appearance. Many of the nerve cells were markedly shrunken.

The tracts as seen by Weigert myelin whole brain sections show much distortion and flattening from the pressure of the hydrocephalus. The corpus striatum is flattened between the body of the dilated lateral ventricle and its equally distended inferior cornu. It gives an elongated appearance in the direction of the fibres of the internal capsule. The latter is sharply outlined and relatively less flattened than the surrounding nuclei. The external capsule and the laminae of the lenticular nucleus are also distinctly demarked. The white matter surrounding the ventricles is deeply stained, shows the fibers to be densely packed or crowded upon each other. In certain places not in direct line of pressure from the dilated ventricles, there are small areas where the white matter and cortex appear fairly normal. The optic tract is greatly reduced to about 1 × 2 mm. in cross section.

The cerebellum showed slight infiltrations of mononuclear cells in the pia mater and about the vessels and there was a slight nuclear increase in the white matter of the cerebellum. The spinal cord showed evidence of pyramidal tract degeneration more markedly upon the right side. There was also in the anterior horn regions of the spinal cord a peculiar cystic degeneration of certain cells, which degeneration seems to have destroyed the nucleus; but it is doubtful whether this change is not a post mortem one.

e) Anatomical and Histological Summary.

The brain of this hydrocephalic imbecile of twenty years weighed, with the contained fluids, 2326 grams, but no doubt far less without the fluid. The most important finding histologically is that of lymphocytosis and plasmacytosis which may be properly used to ground a hypothesis of a syphilitic origin of this case of hydrocephalus. The mechanical origin of the hydrocephalus is evidenced in the blocking by neuroglia tissue of the aqueduct of Sylvius.

Synopsis of Findings, Case XIII.

a) Clinical.

1. Physical Examination.— C. Woe. Female, born Nov. 1, 1896, died May 26, 1915. She was admitted at 8 years of age. At 17 years, patient was 4′ 6½″ tall and weighed 72½ lbs. She later increased over 12 pounds in weight. Patient was fairly developed and nourished, a mouth breather. Skin was coarse, circulation poor, heart sounds weak (systolic murmur at apex), heart enlarged. Fingers and toes were short and blunt. Circumference of cranium was 20″, cephalic index 81. Face asymmetrical, lids inflamed, nose flattened, tonsils large, tongue fissured. Wassermann test for syphilis negative.

2. Family History.— The family history of this case was worked up elaborately by Miss E. C. Macomber. Patient was the first of two children, of a father 35 years of age and mother 27 at her birth; delivery difficult, bleeding of cord for some time until tied. Patient's brother two years younger is normal. Parents: German father freed from military service on account of enlarged heart, married at 34; later had asthma and gastric ulcer; at about 30 years had epileptic seizure, two more after marriage; one just previous to birth of patient. Gouty, asthmatic, bronchitic, and died of paralytic shock; there were three shocks, the third was followed by convulsions. Was a bank auditor, of violent temper; violent headaches; two years after birth of patient remained almost blind for two years. At times sexually ascetic for long periods. Drank great quantities of liquor.

There is asthma, nervosity, paralysis, paralysis agitans and a question of insanity in the father's fraternity and the grandparental fraternity on the father's side.

Patient's mother had one convulsion during teething, was in general normal; was frightened during her pergnancy with this child by her husband coming home after an epileptic seizure; patient's mother regarded the fact that her daughter was born with swollen tongue as due to a maternal impression from

the cut and swollen tongue of her husband. Two brothers were epileptic, alcoholic and tuberculous. A sister had tuberculosis, another had ovarian tumor, a third was backward. Two brothers and one sister are described as normal. As to one sister nothing is known except that she had a miscarriage. A distant cousin had Dementia Praecox (Worcester State Hospital) and her brother was feeble-minded, probably a victim of spastic paralysis.

3. **Personal and Developmental History.**— It was noticed that patient was peculiar at two years; peculiarity was marked at $1\frac{1}{2}$ years; she began to walk and talk at two and a half years; was never able to say such words as " or " or " if "; did not know the alphabet, could not read or count. She was tidy and could aid in dressing and undressing herself; could use a spoon but not a knife and fork, could not tie shoestrings. Described as sometimes obedient, liked picture books and blocks.

4. **History of School Progress.**— Nil.

5. **School examinations.**— Nil.

6 and 7. **Practical Knowledge and Economic Efficiency.**— See No. 3 above.

8. **Social History and Reactions.**— Quiet; inattentive; name had to be spoken to secure attention.

9. **Moral reactions.**— Pleasant and willing.

10. **Psychological Tests.**— 3.1 Binet performed July 13, 1914.

Waverley School History.— Training class records show incapacity at wood work and sewing. Patient was very slow at picking up papers and pins; was able at $10\frac{1}{2}$ to play circle games, simple relay races, could chase the ball and catch a football, and at 12 years is described as clever at playing games. She had by this time learned to tie a knot in thread, to sew without help, and to use scissors well. Yearly records are available from 1905–1909 and a slow but definite improvement is to be noted therein. Patient changed under training from a repulsive, drooling, finger-sucking, untidy, stupid patient, taking short choppy steps and unable to jump more than $1\frac{1}{2}$ feet and to make other simple manoeuvres in games (June 1906) to a tidy patient who had completed the first course of training and had begun to take part in manual training. The patient was subject to frequent colds, sore throat and stomatitis; her circulation was poor, she was subject to infections of various kinds; she had bronchitis and mumps. She was admitted to the hospital April 23, 1915, with severe bronchitis and pleurisy with friction rub; the fever disappeared from time to time. There remained marked dullness at left base; there was foetid odor and patient died May 26, 1915.

b) Autopsy.

Body of a slender, fairly nourished white female, 139 cm. in length. *Skin* rosy white except for freckles over arms and hands and liberally over face.

Scars.— Right upper arm 10 cm. from acromion, measures 4.0 cm. in diameter. *Left lower leg,* 9 cm. below patella two scars 1.0 × 2.0 cm. in diameter.

Post mortem lividity in dependent portions.

Skin slightly scaling below breasts and below costal margins. *Breasts* measure 5 × 7 cm., no pigmented areoli but outline of non-pigmented area 2.5 × 2 cm. surmounted by nipple, which is 0.6 × 0.7 cm. Breasts are placed high on thoracic wall 3 cm. below clavicle and above the fourth rib. *Left thorax* bulges slightly.

Mons is plump. *Hair* scant, represented by few scattering long hairs. *Genital cleft* long, begins 5 cm. below top of symphysis and measures 7 cm. in length × 1.4 cm. in width. *Labia majora* somewhat edematous. Hood of clitoris redundant, measures 1.4 × 0.9 × 1.0 cm. *Labia minora* are prominent, size unequal; left measures 0.4 × 2.0 cm., right 0.4 × 3.0 cm.

Pupils. — Right and left 0.5 cm. Palpebral fissure 2.4 cm. on each side; seems insufficient for eyeballs.

Face somewhat asymmetrical; right side below cheek-bone somewhat flattened. Nose shows cracking at bases of alae. Lower lip cracked.

Teeth unequal; some broad, some narrow, and not evenly placed. Marked retraction of gums of lower jaw.

On left of tongue near tip is an island of tongue tissue which is separated from the remainder of the tongue — is sessile in character, superimposed on surface and measures 1.0 × 1.5 cm. Palatine arch fairly broad.

No lymph nodes palpable; no edema.

Superficial decubitus over sacrum, measures 1 × 3 cm. Multiple *abrasions* right trochanter major. Over elbows there is a greyish brown, raised, granular appearance on the folds of the skin for an area of 2.0 × 3 cm.

Umbilicus appears protuberant.

Ventral Section.— Fat over abdomen 0.7 cm., over thorax 0.5 cm. Muscles red. Sternal length 14.0 cm., ensiform bifid. Costal arch broad. Lower border of liver 8.0 cm., stomach 11.0 cm., transverse colon 21.0 cm., below ensiform. Omentum large, scant in fat. *Intestines* white. *Appendix* points across the top of the true pelvis, is bound down by adhesions, has a mesentary to tip, measures 9 cm.

There is free fluid in the pelvic cavity, estimated amount 40 cc. Bladder contracted. Uterus drawn to right. Ovaries fairly normal in size. Mesenteric, bronchial, and retroperitoneal lymph nodes markedly enlarged, measuring in the mesentery 3.0 × 1.0 cm.; in the retroperitoneal, 3.0 × 1.0 × 1.0 cm.; in the bronchial, 2.0 × 3.0 × 2.0 cm.

Diaphragm arches to the fourth rib on the right, fifth on the left.

Thorax.— *Anterior mediastinum* shows thickening of its tissues. Mammary vessels stand open on section. *Sternal marrow* is scant, is brownish-pink in color, and appears paler than is usual. *Right pleuric cavity* contains fluid up to mid-axillary line. It is turbid and yellowish in color. *Left pleuric cavity* obliterated by firm adhesions down to the axillary line, release of which reveals yellow turbid material which is blood stained. *Pericardial sac* distended, contains excess of clear fluid. *Surface* of heart is granular and white over the inferior surfaces and on its lateral borders. There is a thymus gland which is embedded in the fat and surrounded by lymph glands.

Heart.— Weight estimated, 175 grams. Apex shows a transverse fissure between the left and right ventricles. Coronary vessels not remarkable. Right auricle dilated with clot.

Measurements: T. V. 9.0 cm. P. V. 6.0 cm. L.V. 0.8 cm.
M. V. 8.0 cm. A. V. 6.0 cm. R. V. 0.3 cm.

At the *apex* of the *right ventricle* there is a collection of purulent white material which is the centre of a firm red-white body which is adherent to and between the papillary muscles, and which covers the apex of the right ventricle. Valve not remarkable. Myocardium not friable. Section shows nothing of note. *Myocardium* slightly grey at the bases of the ventricles.

Lungs.— Weight: right, 680 grams; left, 705 grams. The *right lung* shows a granular, even increase of fibrous tissue over surface with multiple nodules yellow in color on the surface. On section, lung is greyish and greenish and dotted over with focal and conglomerate tubercles. Foul odor on section of lower portion.

Left lung, same description for outer surface except at a point near the diaphragm on the superior surface. There is a *rupture* in the pleuric wall which leads to a necrotic cavity that is foul smelling, separated from the rest of the lung by a broad band of fibro-gelatinous tissue. The *cavity* extends throughout the lower lobe. The *apex* shows peribronchial caseous areas. Peribronchial lymph nodes enlarged as before mentioned.

Organs of the Neck.— Thyroid only removed. Weight 28 grams approximately. Shows nothing of note. Thymus gland as before mentioned.

Abdomen.— Spleen: Weight, 195 grams; measures 13 × 9 × 3 cm. Capsule not thickened. Color brilliantly red; increased number of Malpighian bodies on section. Marked congestion in layers near surfaces. No increase of trabeculae.

Adrenals.— Measure 4.0 × 1.5 a 0.4 cm. Cortices are small and the central portion is unevenly brown.

Kidneys.— Combined weight, 650 grams. Perirenal fat stringy and scant. Capsule strips with ease; is not thickened. Cortex measures 0.5 cm., swells over capsule on section, is grey, not well differentiated from pyramids, which are themselves liberally streaked with white. Same description for other kidney.

Liver.— Weight, 1415 grams. Measures 21 × 17 × 7 cm. Superior surface shows thickening of capsule. There is a tracery of thickening over the entire surface. Color reddish yellow. Section shows marked increase of interlobular substance. *Gall-bladder* small, contains no stones. Content of *bladder* granular yellow fluid.

Pancreas.— Negative.

Gastro-Intestinal Tract.—Negative on sections examined except submucous hemorrhages near fundus of stomach.

Genito-Urinary Tract.— Bladder small, contracted; measures 7 × 4 × 2 cm. Inner wall somewhat pink. Vagina measures 1.8 cm. in diameter. Cervix and lower uterine segment indistinguishable. Os is a transverse slit. Uterus measures 5 cm. in entire length × 1.5 cm. in breadth at cervical end and 3 cm. in breadth at fundus. Interior of uterus and lower uterine segment negative. Ovaries appear to be distinctly fibrous in internal structure — question of small cysts.

Retroperitoneal Tissues.— Retroperitoneal glands either side of aorta numerous and red. Aorta 2.0 cm. in circumference. There are small, raised plaques of thickening in posterior walls. Sympathetic and peripheral nerves negative in appearance.

Head.— Circumference of head at frontal eminence, 50 cm., mento-bregmatic, 9.5 cm., and mento-occipital, 36 cm. Mastoid to mastoid, 33 cm. (anterior measurement), interparietal, 20 cm.

Hair, auburn, abundant. *Bruises* in scalp and periosteum over vertex.

Calvarium measures 0.4 cm. frontal, 0.3 cm. temporal, 0.4 cm. occipital.

Sutures and fontanelle show thinning, and there are irregularities in the thickness of the calvarium.

Grooving for middle meningeal arteries shallow. Dura thickened especially along the longitudinal sinus and in the distribution of the middle meningeal artery. Longitudinal sinus contains post mortem clot. There is scarcely any fluid beneath the pia mater, which itself is thin and delicate. Artefacts are produced in the second left temporal, in the inferior parietal region, and slightly in the second and first temporal on the right.

The dura is markedly adherent along the left side of the longitudinal fissue where the Pacchionian granulations are thickest.

Greatest length of the brain on left, 17 cm.; on right, 16 cm.

Greatest width of brain, 14 cm.

The pial veins are markedly injected and full, especially on the left. The largest vein over the vertex is anterior to the fissure of Rolando. Veins on the right are apparently equal in size.

The *frontal convolutions* are unequal, the left being smaller than the right. The *motor convolutions* are exceedingly unequal, the right precentral measuring 0.5 cm. in width, the left measuring 0.9 cm. The right postcentral, markedly prominent, measures 3 × 1.5 cm.; the left measures 2 × 1.5 cm. The *parietal regions* are markedly unequal, the right being more prominent. The *occipital lobes* are markedly unequal, the left being more complex than the right. *First temporal* on the left is smaller than the right.

At the Base.— The olfactory bulbs are adherent to the skull. The optics are somewhat edematous in appearance.

Vessels.— The vertebrals are apparently of equal size. Basilar is small, the branches normal and equal. Marked depressions in the orbital surface of the frontal poles.

Brain Weight, 1160 grams. Tigges' formula, 8 × 139: 1112 grams. Gain of 48 grams.

Base of Skull.— Posterior clinoid processes are perpendicular to the foramen magnum, and the middle clinoid processes are apparently obliterated. The *pituitary body* is tipped backward and nearly covered by an overhanging projection of the sphenoid in the mid portion of the anterior sellar curve. The pituitary body is broader than it is long. The gland portion appears fibrotic.

Gasserian ganglions and middle ears are negative.

Cord negative except in the lower thoracic segments where there is a bulging and softening. Cross section shows marked change in grey matter of a hemorrhagic nature.

General Appearance and Anomalies.

Slenderly built
Scars on extremities.
Thorax bulges one side.
Asymmetry face.
Short palpable fissures.
High placing of breasts.
Long genital cleft.
Prominence of clitoris.
Inequality of labia.
Persistence of thymus gland.
Abnormal mobility of sterno-clavicular junction.
Island of tongue tissue.
Non-development of generative organs.

Ductless Gland Changes.

Pituitary fibrotic (?).
Thyroid gland small.
Thymus gland persistent.
Marked enlargement of lymph nodes (bronchial, mesenteric, retroperitoneal).
Microadrenia.
Ovaries fibrotic.

Acute Lesions.

Tuberculous bronchopneumonia.
Pulmonary gangrene.
Hydrothorax.
Acute fibro-pericarditis.
Purulent thrombosis, right ventricle.
Acute parenchymatous nephritis.

Chronic Lesions.

Sclerosis of aorta.
Chronic fibrous endocarditis, ventricular.
Chronic interstitial hepatitis.

c) and d) Special Anatomical Description of Brain and Microscopic Examination.

The brain seems actually heavier than the body length of this Mongolian imbecile would suggest. But this disparity is perhaps due to a disproportionate shortness of the body of the subject rather than to any disproportionately large size of the brain.

There are certain inequalities in the gyri, the left frontal, left precentral and right postcentral being smaller than their fellows. The right parietal region was more prominent than the left and the sulcation of the left occipital region was more complex than the right.

Microscopically there was a moderate increase in neuroglia fibres throughout the subpial areas wher-

ever examined, but there was, on the whole, very little increase of neuroglia cells either of a general distribution or of a perivascular or pericellular distribution. There were rod cells frequently to be seen and many small pyknotic nuclei of cells with short protoplasmic processes in the white matter. Very rarely occurred slight thinness of vessel walls. There was nowhere in the numerous sections studied any evidence of exudative cells.

There was everywhere an apparent thinning out of the nerve cells varying somewhat in degree with location. When the two postcentral gyri were compared (the left measuring far less than the right) it was found that the nerve cells were far less frequent in the postcentral gyri on the left (or narrow) side than on the right. But this comparative situation cannot be said to be sufficiently marked to warrant generalization.

On the whole the main effects in this Mongolian brain appeared to be a moderate subpial gliosis and a moderately extensive somewhat locally variable diminishing in the number of nerve cells.

e) Anatomical and Histological Summary.

The brain of this Mongolian imbecile weighed 1160 grams, an apparent excess in weight as compared with the body length. The patient had lived eighteen years, dying at last of pulmonary tuberculosis with gangrene but before any marked deterioration characteristic of the Mongolian imbecile had begun to set in. The absence of evidence of chronic exudate in this brain, as so far examined, is of interest. From the standpoint of the endocrine possibilities in Mongolian imbecility it may be noted that there was a persistent thymus, that the pituitary had undergone chronic changes, that the thyroid and adrenal glands were small and that there was a marked enlargement of various lymphnodes.

Synopsis of Findings, Case XIV.

a) Clinical.

1. Physical Examination.— C. Wel. Male, born August 5, 1882, and died June 6, 1915; patient admitted at 16 years, 2 months, Oct. 29, 1898, as a custodial case.

Left testis undescended, abdomen prominent; cranium and face asymmetrical, left ear deformed; circumference of cranium at 31, 21½ inches, cephalic index 76. At 31 height 5′ 3″ and weight 142 pounds.

2. Family History.— Patient one of 12 children and at time of patient's admission at 14, 3 children had died of tuberculosis, meningitis and diphtheria respectively. The father, intemperate, 50 years of age, and mother 31 when patient was born; pregnancy normal.

3. Personal and Developmental History.— Patient began to walk at 2 years of age; first peculiarity was stated to have been noted at 6 after an attack of scarlet fever when patient became unable to talk for a time.

4. History of School Progress.— Nil.

5. School Examinations.— Nil.

6 and 7. Practical Knowledge and Economic Efficiency.— Patient took part in outdoor working classes at the school, learned to pick and handle stone and to use grub hoe and shovel, and in school house polished floors and helped with cleaning. Patient very slow and deliberate in his movements, never able to do work requiring thought.

8. Social History.— Easily managed.

9. Moral Reactions.— Quiet; no masturbation.

10. Psychological Tests.— 1.3 Binet performed Sept. 26, 1914, the year of his death.

Waverley School History.— Patient was never strong but had no severe illnesses except the last one. Ulcerative skin lesion with surrounding areas of pigmentation appeared in the winter of 1914–15. These were cleared up by sulpho-naphthol, iodides and arsenic; there was simultaneously a keratitis, it was resolved into an ulcer of the cornea of the right eye; the left eye was also affected. A cough developed, with loss of appetite, weight and strength. The lungs proved to be tuberculous and there was enlargement of the cervical lymph nodes.

b) Autopsy.

Body of a slenderly built, poorly nourished white male, 159 cm. in length. *Skin* greyish in color; is the seat of innumerable small brownish areas, in the centre of which are for the most part punctate, depressed, tissue-paper-like scars which are thickly set over thorax between the nipples and over the abdomen, and increasing in size and in number over the lower extremities; beginning at the knees, the diameter varies from 0.9 cm. to 2 cm. On *left leg*, anterior surface, there appear scars and scabs measuring 2 × 2 to 0.8 × 1 cm. On back, the appearance duplicates that on thorax.

One large lymph node superior and posterior to the sterno-clido-mastoid muscles measure 5 × 3 cm. No other palpable lymph nodes in body. No edema nor decubitus.

Pupils.— Right 0.4 cm., cornea the seat of ulcer which clouds it. Left pupil measures 0.5 cm.

Teeth.— Few missing. Gums opaque.

Ears.— Left pinna different from right, flattened out in lower half. Small abrasion in the midst of flattened portion. Abrasion of pinna of right ear.

Ventral Section.— Fat over abdomen 1.0 cm.; fat over chest 0.3 cm. *Muscles* fairly deep red in color. *Peritoneum* somewhat thickened. Lower border of liver 5 cm., of stomach 9.0 cm., transverse colon 25 cm. below ensiform. *Omentum* scant in fat. *Intestines* somewhat injected. *Appendix* retrocecal, bound down by adhesions, is coiled, measures 7 cm. *Ileum* also bound down by adhesions. Descending colon loops in pelvis. *Spleen* free except at lower border. Diaphragm arches to the fourth interspace on the right and to the fifth rib on the left. *Mesenteric lymph nodes* not enlarged. Slight slipperiness of pelvic cavity but no collectable fluid.

Thorax.— Mammary vessels stand open on section. Inner surface of sternal marrow raspberry red in color but not abundant. Slight amount of blood-stained fluid on right thorax, same on left. The lungs do not meet in median line.

Heart.— Epicardial fat present. Coronaries, descending branch of left show nothing of note. Right collapses on section; contains some red clot. Right auricle distended by red and white clot, latter portion of which is elastic.

Measurements:	T. V. 11.5 cm.	P. V. 8.0 cm.	L. V. 1.0 cm.
	M. V. 10.0 cm.	A. V. 7.0 cm.	R. V. 0.6 cm.

Myocardium greyish in color and friable. Endocardium slightly greyish. Pericardial sac contains excess of clear straw-colored fluid. Adhesions bind left lung to chest wall and are difficult to break up.

Lungs.— Weight: left lung, 1090 grams; left lung shows thickening posteriorly and is a pinkish red color. *Apex* shows nodular bodies on palpation. *Base* shows congestion. *Upper lobe* shows multiple cavities, the largest measures approximately 5 × 5 cm. Remainder studded with yellow areas 0.2 to 0.4 cm. Right lung firm; section of lung shows yellowish grey areas around bronchi.

Organs of the Neck.— Base of *tongue* covered by yellowish mucus. Foramen cecum is indicated. Mucous *glands* scattering. *Esophagus* negative. Glottis apparently somewhat wrinkled. *Vocal cords:* left false and ventricle between it and true cord covered with yellowish puriform material arranged in circular and colony form. Right one, true cord, shows an aperture at its outer third which yields brown yellow material.

Thyroid.— Negative on inspection. Parathyroid present. Lymph nodes below thyroid abundant,

but no special gland tissue seen. One lymph node measures 5 cm. in width, is yellow, and on inspection shows upper two-thirds caseous, lower third pigmented and sharply defined.

Abdomen.— Spleen: Weight, 230 grams.

Adrenals.— Large and flat. Nothing of note otherwise.

Kidneys.— Weight: right kidney, 95 grams. Capsule thickened. Kidney substance; cortex swelled over capsule, on section measures approximately 0.6 cm. Kidney measures 9.5 cm. × 4.0. cm. Pyramids well differentiated, injected at bases, streaked white at apices.

Liver.— Measures 21.0 × 18.0 × 7.0 cm. Inferior edges blunt. Capsule slightly thickened. Color bluish red. Section shows nothing of note.

Pancreas.— Negative.

Gastro-Intestinal Tract.— Negative.

Genito-Urinary Tract.— Not examined.

Retroperitoneal Tissues.— No enlargement of lymph nodes around aorta. Aorta small, no thickenings. Peripheral nerves negative.

Head.— Scalp shows growth of rather thinly placed hair. Some scars over vertex. *Scalp* adherent to the calvarium.

Calvarium: Frontal bone 0.5 cm., temporal 0.3 cm. to 0.5 cm., occipital 0.6 cm. Bone dense, no differentiation between tables. Grooving for middle meningeal arteries shallow. Some difference in thickness of calvarium noted along sutures.

Dura mater not adherent — somewhat thickened along distribution of the middle meningeal arteries and on either side of longitudinal sinus, which latter contains slight amount of greyish yellow clot.

Convolutions seen through dura mater generally, but only at focal points over frontal pole.

Pia is somewhat injected. Pia shows foci of thickenings over vertex; small collections of fluid in scattered areas.

Base of brain.— Olfactory bulbs are degenerated and adhere to skull. Optic nerves not remarkable.

Stalk of pituitary and space between it and mammillary bodies is covered by a red exudate. This involves the middle cerebrals, and third and fourth nerves. Stained specimen shows no tubercle bacilli.

Basal arteries show nothing of note except inequality of size in the posterior cerebral branches. Temporal tips firm and equally marked.

Frontal portion of *brain* shows minute and slender sulcation. Pressure ring around medulla. Fourth ventricle bound down by adhesions.

Superior surface of the brain.— Frontal portion is rounded; hemispheres appear equal but posterior two-thirds of the brain are not proportionate to anterior third. Cerebellum protrudes behind occipital tips. Occipital tips themselves appear unequal and bifid at their extremities. Parietal lobes are unequal; right smaller than left but the turnings of the convolutions more complex. Palpation shows the brain to be slightly and equally increased in consistence, especially frontally. First temporal, which disappeared on left in anterior third, is continuous on right.

At *the base of the skull* the pituitary is visible through the membrane for a space of 1.1 cm. in length by 0.5 cm. in width. Posterior clinoid processes are smooth and do not protrude. The middle clinoid is invisible; anterior clinoid small.

Pituitary shows no change.

Middle ears not notable. *Optic discs* unequal. The orbital plates show accessory sinus on the right side.

Brain weight, 1205 grams. Tigges' formula, 8 × 159; 1272 grams. Loss in weight 67 grams.

Cord not notable.

General Appearance and Anomalies.

Poorly nourished.
Abrasions and scars on body.
Corneal ulcer
Unequal pupils.
Unequal ears.
Narrow costal angle.
Unequal posterior cerebral arteries.
Fissuration simple in brain.
Occipital tips notched.
Unequal temporals.
Unequal parietals.
Unequal optic discs.
Middle clinoids missing.

Acute Lesions. None.

Chronic Lesions.

Corneal ulcer.
Fibrous pleuritis.
Pulmonary tuberculosis.
Hydropericardium.
Hydrothorax.
Tuberculosis vocal cord.
Tuberculous peribronchial lymphnode.
Enteroptosis.
Periappendicitis.
Interstitial nephritis.
Scalp adherent.
Calvarium thick.
Calvarium dense.
Dura thick.
Subpial edema.
Olfactory bulbs degenerated.
Brain weight 1205 grams.

c) and d) Special Anatomical Description of Brain and Microscopic Examination.

Noteworthy is the protrusion of the cerebellum behind the tips of the occipital lobes when the brain was observed from above. The frontal poles had a rounded off appearance and the anterior of both hemispheres struck one as disproportionately large when compared with the posterior two-thirds.

Microscopically there was found an occasional area with focal perivascular infiltration of larger and smaller mononuclear cells, the larger cells strongly suggestive of plasma cells. (Left upper post central gyrus, right post central gyrus.) But there were numerous areas in which careful examination revealed no perivascular infiltrations whatever.

The neuroglia tissue showed a moderately slight increase of cells in the outer layers of many areas though apparently quite absent in some. In some areas there was a slight general increase of neuroglia cells in the white substance whereas in other areas there was none. Satellitosis was moderately marked in various regions but entirely absent in others.

The most important finding amongst the nerve cells was their frequency in the white matter in certain areas (left upper precentral gyrus, right upper precentral gyrus, right superior temporal gyrus, right angular gyrus). This heterotopia of nerve cells no doubt argues a very early development of the condition. Some areas show an apparent scarcity of nerve cells whereas others fail to show any marked scarcity.

There is an interesting microscopic focality about the lesions in this case. The right upper post-central gyrus, for example, shows a focal enlarging of the cortex over the crowns of the gyri which is even evident in the gross. The cell scarcity here was marked and affected especially the medium sized pyramidal cells of the suprastellate layers and the internal large pyramids. A section from the right superior parietal region showed much general scarcity of nerve cells with several foci of almost complete cell destruction visible in the stained section when examined in the gross. There was here a development

of genuine encephalitic foci and underneath this gyrus there was a considerable glia cell increase in the white matter.

The tracts as studied by whole brain sections prepared by the Weigert myelin sheath method were on the whole intact. In the frontal region the gyri recti on both sides extended a considerable distance beyond the rest of the convolutions: a normal proportion exists between white and grey matter.

Through the temporal tips the ventricles were not enlarged. The two laminae of the septum lucidum are intact. The fibers of the internal capsule are well marked.

There is nothing abnormal in the general contour and relationship of the nuclei of the corpus callosum striatum.

The fibers of the corpus callosum are deeply stained. The external capsule is distinctly outlined.

In the region of the posterior commissure the white fibre tracts in general and the callosal, internal and external capsular tracts in particular are well defined. The fibers are visible surrounding the red nucleus and the locus niger.

A cross section in the region of the splenium of the corpus callosum shows nothing abnormal in the white matter.

The small vessels are seen throughout piercing the white matter in a normal way.

e) Anatomical and Histological Summary.

The occurrence of focal lymphocytotic deposits in at least two areas of the brain of this thirty-two year old patient brings up the question of its possible syphilitic origin. Possibly we should not go too far in insisting upon syphilis when a few areas of lymphocytosis are found. The fact that there were also polymorphonuclear leucocytes in one of the areas showing mononuclear infiltration was not noted above in the microscopic summary but was reserved for comment here: does this perhaps indicate that the lymphocytes in this case were part and parcel of some other process than a syphilitic one? Symptoms in this case are said to have developed after a scarlet fever at six years. The occurrence, in several areas, of nerve cells in the white matter — that is to say, a definite heterotopia of nerve cells — does not appear to suggest necessarily neurosyphilis. On the whole it would not seem wise to push the correlation of lymphocytosis with neurosyphilis too far. On the whole the brain suggests arrested development rather than a phenomenon of syphilis.

Synopsis of Findings, Case XV.

a) Clinical.

1. **Physical Examination.**— Wm. McK. male, born about 1871, was admitted at 43 years, and died less than a year later, January 20, 1915. Patient was thin and weak at entrance, showed rales in the chest, had dry skin and somewhat enlarged heart with indistinct sounds and non-transmitted systolic murmur at apex; enlarged area of liver dullness, slightly enlarged abdomen, well developed limbs; diminished patellar reflexes. Cranium circumference 21″; decayed teeth.

2. **Family History.**— Patient's sister was admitted to the School at the same time as patient; another sibling is dead; patient's aunt and children mentally deficient.

3. **Personal and Developmental History.**— The head was remarked to be small. Patient is described as lacking somewhat the sense of taste, as understanding language and commands only in part; was able to dress and undress himself with help and feed himself.

4. **History of School Progress.**— Probably none.

5. **School Examinations.**— Nil.

6 and 7. Practical Knowledge and Economic Efficiency.— Patient performed a few duties about the building, such as rubbing the floor and did small amounts of work in the dining room.

8. Social History and Reactions.— Patient willing and kind.

9. Moral Reactions.— Quiet; described as of passionate temper at times and at times disobedient.

10. Psychological Tests.— 2.4 Binet performed in 1914.

Waverley School History.— Patient's physical condition improved somewhat after arrival but in the middle of the winter, patient became less active and despite hearty appetite, gradually lost weight; later his appetite failed; there was no temperature or pain. Patient took to bed and died June 20, 1915, of abscess of the liver.

b) Autopsy.

Body of a slenderly built, fairly well nourished white male, 152 cm. in length. The *skin* is yellowish grey in color except for some excess pigmentation about the neck, which is brown in color, slightly over left cheek-bones and hands. Post mortem lividity in dependent portions. No bed sores.

There are *abrasions* over knees measuring 2 × 1 and 3 × 3 cm. Small tissue-paper scars over left lower thigh, right knee, and left shin.

Toes on left foot short; second and third held together for one third proximal distance by "webbing." The third toe on right foot is longer than the second and is curled under it. No such tendency in hands.

Penis small; prepuce redundant. Hair abundant over abdomen to above umbilicus, and grows on areoli of nipples. Apparent *accessory nipple* on right. No lymph nodes palpable. Abdomen is somewhat distended. Umbilicus shows beginning obliteration. Recti muscles feel separated.

Square, short jaw; teeth foul.

Pupils measure: right 0.3 cm., left 0.3 cm. Hairs on lower eyelid scanty, especially right, and mucoid discharge apparent. No marked asymmetry of face. Ears small but lobes not adherent.

Ventral Section.— Fat over abdomen 1 cm., over thorax, 0.4 cm. It is pale and dryish. The muscles are red but not firm. Lower border of the liver is 7 cm., transverse colon 15 cm. below ensiform. The lowest portion of the right lobe of the liver reaches to within 7 cm. of the anterior superior spine. The *intestines* are injected irregularly and markedly distended. The *spleen* is adherent and the *stomach* is dilated and pale. The *appendix* measures 8 cm. and is free. There are no mesenteric lymph nodes notable but peritoneal nodes are large, measuring 2 to 3 cm. in length, though pale in color. There is a little *free fluid* in the peritoneal cavity, especially in the pockets formed by looping of the intestines and adherence of the gall bladder. The *diaphragm* arches to the fourth interspace on the right side but is not measurable on the left. The *liver* itself is bound to the wall of the abdominal cavity by firm adhesions. The costal angle is broad.

Thorax.— The lungs are adherent to chest wall at upper portion of left and in the entirety on the right. The peritoneal sac is not tense.

Lungs.— Weights not taken. Right shows brilliant red color at base and superficial scarring at apex. The lowest portion of the lung is friable, deep red, bronchi markedly injected. The left lung shows the same change, and added to this a purulent fluid in the bronchi.

Heart.— Measurements and weight not taken. Coronaries smooth. Epicardial fat normal in amount. Myocardium red and friable. Tricuspid valve measures approximately 10 cm.; free edges somewhat thickened. Pulmonary valve measures 7.0 cm., mitral 9.0 cm., and its free edges are somewhat thickened; aortic valve, 8.0 cm., irregular thickenings of the valve leaflets. Left ventricle measures 0.8 cm., right 0.3 cm. There is no thickening of the arch of the aorta and the remainder of the aorta appears smooth.

Organs of the Neck.— Base of the tongue rough. Tonsils not removed. Epiglottis shows some tracery of injection. Rima glottis shows some general diffuse reddening. The esophageal portion of the larynx is injected, reddish blue in color, for an area extending from the base of the tongue to the upper

portion of the thyroid cartilage. The mucous membrane shows a few fine wrinkles but is not otherwise remarkable. The vocal cords appear equal and well developed. The thyroid is large, has two lobes and a well-defined isthmus, and there is nothing of note on section.

Abdomen.— Spleen measures approximately 12 × 8 × 2 cm., is soft and flabby. On section, pulp scrapes easily, is irregular in color, there being some paling of the parenchyma and some marked hemorrhages. Trabeculae markedly increased. No Malpighian bodies seen.

Adrenals.— The left is somewhat injected, but the right is brilliantly red in its entirety.

Kidneys.— The right kidney is adherent to the under surface of the liver, and upon being removed, the knife slips into a huge cavity and removes the wall of the cavity which is adherent to the capsule of the kidney. The color of the kidney is extremely yellowish pink, and the cortex measures 0.7 cm. in thickness. There is some slight tracing of red on the surface of the cortex, and there is some suggestion of paling of the apices of the pyramids; otherwise nothing of note. The intestines, pancreas, and liver were removed together, and on separating the ascending colon at a point on the under surface of the liver to which it was adherent, a large amount — approximately 500 cc.— of dirty, greenish grey, semi-fluid content escaped.

Liver.— Approximate measurements, 29 × 25 × 8 cm. The external surface uncovered by adherent diaphragm is yellowish pink in color and the inferior edge is blunt and fluctuant. On inspection of the fluctuant area, there is seen to be an irregular gangrenous change extending to the central portion of the right lobe of the liver, measuring approximately 9 × 7 cm. The inner surface of the cavity is criss-crossed by blood vessels surrounded by softened necrotic substance as noted under kidney. Smaller sections through the edge of the abscess show slight reaction to it, though there are small pus pockets in the more normal liver tissue within a limit of one centimeter from the irregular inner edge of the abscess. Direct inspection for amoebae was made but none seen. The type of cell displayed for the most part was polymorphonuclear leucocytes, with marked bubbles or droplets resembling fat, which took up a brilliant red color on exposure to Sudan III in a mixture of 70% alcohol and acetone of equal parts. Smears stained with hematoxylin (Tyzzer) especially for amoebae, show none, and no organisms are found by special stains — Ziehl-Neilson, Gram, etc.

The *gall bladder* contains 18 faceted stones; some of them are in the cystic duct. No pus nor induration around the wall. No enlarged lymph nodes.

Pancreas pale in color, not notable.

Gastro-Intestinal Tract.— Not examined in its entirety but various levels examined with negative results. There is no change in the mucous membrane except for a curious, homogeneous, black stippling of the mucous surface. (This appearance has no parallel in previous experience of examining intestines except in the lower animals.)

Genito-Urinary Tract. The bladder is small, is pointed at its fundus, and the mucous membrane is negative. Prostate not examined. Testes thread well.

Head.— Scalp thick and adherent to the bone. Junction between frontal and temporal bone marked by a ridge measuring 8 cm. Calvarium measures, frontal 0.3 cm. to 0.6 cm., temporal 0.2 to 0.5 cm., occipital 1 cm.

Dura mater adherent along centre of vertex. Depressions in inner table due to exuberant pacchionian bodies. Grooving for middle meningeal arteries uneven, being more shallow on the right side. Dura mater is thick and yellow, especially in the distribution of the middle meningeals. The frontal convolutions can be seen through it. The longitudinal sinus contains chicken fat clot, otherwise free.

Turning back the dura mater, the *pia mater* is seen to be slightly thickened along the vessels, and the vascular distribution is somewhat unequal. A large vein at the vertex on the left side shows a backward turn of approximately 1 cm., after which it goes to the extremity of the frontal pole. There is no such arrangement on the right. Small collections of fluid appear beneath the pia.

The frontal convolutions which run antero-posterior, merge into the precentral regions with no

appreciable differentiation, there being a distinct triangle formed from the third frontal and the Rolandic-mesial junction. On the right, it is even more striking, this poor marking of the regions of the brain. Excess fluid at the base of the brain.

At the *base of the brain* the olfactory tips appear slightly yellowish, tracts are thin. The optic nerves appear somewhat unequal, the right being more nearly flat. The third nerves appear intact but are slightly involved in a thickened pia, which binds them to the sides of the basilar artery. The fourth nerves are free; the fifth nerves appear somewhat bound by a thickened pia; sixth nerves the same; seventh nerves negative; eighth also negative.

The basilar artery is wide and soft, as are the other branches of the circle of Willis. Slight amounts of ante mortem clots show in the left middle cerebral.

Slight amount of pressure lipping on each lobus pyriformis. The pons is remarkably prominent and firm to the touch, as are the pyramidal tracts and olivary bodies. The fourth ventricle appears to be free from granules.

There is marked firmness of the hippocampal gyri; the occipital tips extend but slightly behind the cerebellum. The first temporal convolution is markedly narrow on the left and its posterior half almost entirely disappears. Same for right.

The *right parietal lobule* is difficult to distinguish from the occipital, and the apparent merging of frontal with precentral appears duplicated in the parieto-temporal. On the left side, the differentiation of the parietal lobule is not difficult, especially the angular.

On palpation there is a general resistance of brain tissue which corresponds with occipital tips. This is especially marked in frontal region but no normal softness obtains unless it be in the left postparietal lobule.

At the *base of the skull*, the opening for the pituitary is markedly contracted. An aperture was approximately 0.6×0.4 cm. surrounding the stalk. The pituitary shows small anterior lobe and large posterior lobe with apparent islands of white tissue and increase of connective tissue.

In the orbital plate on the right is a small sinus lined with purulent material, stained smear from which shows, *Gram stain*, scattered cocci, polynuclear cells, and also lymphocytes. By Ziehl-Neilson stain, no tubercle bacilli.

This sinus cavity measures approximately 0.6×0.4 cm. Right ear drum and mastoid cells are bathed in pus, Gram stained specimen of which shows many cocci (some in chains), and polynuclear cells. By Ziehl-Neilson stain, no tubercle bacilli seen.

Brain weight 1070 grams (3 hours later). Tigges' formula, $152 \times 8 = 1216$ grams. Loss of 156 grams in weight.

External Appearance and Anomalies.

Fairly nourished.
Abrasions and scars extremities.
Pigmentation neck, face and hands.
Hirsute.
Webb toes.
Genitalia small.
Redundant prepuce.
Accessory nipple.
Reversion in intestinal tract.
Calvarium thin.
Unequal grooving middle meningeals.
Frontal lobes and central convolutions anomalous.
Unequal optic nerves.
Irregular bony growth skull.

Acute Lesions.

Myocarditis.
Injection larynx.
Purulent mastoiditis.
Purulent otitis media.
Purulent blepharitis.
Purulent bronchitis.
Liver abscess.

Chronic Lesions.

Splanchnoptosis.	Dura thick.
Perisplenitis.	Leptomeningitis.
Interstitial splenitis.	Subpial edema.
Perihepatitis.	Pressure pointing lobus pyriformis.
Ascites.	Sclerosis pons.
Adhesive pleuritis.	Gliosis hippocampal gyri.
Fibrous endocarditis.	General cerebral gliosis.
Fatty kidneys.	Interstitial pituitaryitis.
Gall stones.	Brain weight, 1070 grams.

c) and d) Special Anatomical Description of Brain and Microscopic Examination.

The brain was throughout of an increased consistency. The overhang of the occipital poles over the cerebellum was very slight. There were a few inequalities of gyri (e. g. left first temporal) but on the whole the brain presents a rather normal appearance in the gross.

Microscopically there seemed throughout the sections to be a considerable evidence of edema despite the fact that the gross consistency of the brain was increased.

There was practically no increase of neuroglia cells either in the subpial regions or elsewhere except that the white matter occasionally showed a slight or moderate gliosis. This absence of any cellular gliosis seems rather inconsistent with the general permanency of the brain tissues. It is possibly due to an old fibrillar gliosis no longer associated with any increase of cell bodies but even this hypothesis has not been supported by our histological study. It is possible that this brain was cut postmortem (fifteen hours) in such a way as to show a prominence of a true edema of the brain. Edema changes as noted above were found in many nerve cells. This special neuropathological problem of the relation of gross consistency to microscopic appearances must be left unsolved.

Of more moment to the analysis of this case is the finding of a few round cells and plasma cells in the meninges in certain areas (right postcentral, right angular, left superior frontal) occasional rod cells were found in areas not always associated with the lymphocytosis. There were a few slight focal peripheral evidences of glia fibre increase. Various areas showed a marked scarcity of cells, for instance the left precentral gyrus showed very few Betz cells and some of those that remained were shrunken and some slightly swollen with eccentricity of nucleus. More definite evidence of atrophy was shown in other areas, for example the right superior parietal region showing in one area a focal enlarging of the cortex with increase of neuroglia in the outer areas over the crown of the gyrus together with some general nerve cell thinning out and a moderate focal increase of neuroglia cells in the white matter.

e) Anatomical and Histological Summary.

The brain of this low imbecile of forty-three years weighed 1070 grams but showing, no doubt, less a condition of atrophy than of aplasia. The different elements in the brain grossly taken seemed proportionate to one another. To be sure the photographs of the gross sections of the brain show posteriorly a certain diminution in the depth of the corpus callosum and the rounded callosal angles of the ventricles may well indicate a certain slight degree of hydrocephalus, presumably not due to any active dilatation of the ventricles so much as to absence of a certain amount of the investing walls.

What is the significance of the plasmacytosis in one area and the lymphocytosis in this same area and in a single other area? Shall we regard this evidence as pointing to neurosyphilis? The fact that there

was an excessive abscess of the liver in this case, say nothing of a marked purulent otitis media and mesenteritis must give us pause in any immediate tendency we might feel to charging the findings up to neurosyphilis. The situation may be neurosyphilitic or the imbecility may be due to some other form of chronic inflammation. These matters require special investigation. The provisional answer appears to us on the whole to be that the case should not be placed in the neurosyphilitic group on present evidence. Still we must feel that the diminution in nerve cells in this case is associated with rod cell increase, that is, with changes in mesenchymal tissues. Possibly these mesenchymal changes are somewhat secondary to the nerve cell changes, yet rod cells on the whole appear to have occurred in tissues subject to chronic inflammatory changes rather than in tissues subject merely to atrophy. We must leave the question in this argumentative phase.

Synopsis of Findings, Case XVI.

a) Clinical.

1. Physical Examination.— D. E. Cur., male, born June 7, 1901; was admitted April 22, 1907, and died Sept. 16, 1915. Patient at 12 years was 3′ 10″ tall and weighed 47 pounds, was poorly developed, fairly nourished; mitral regurgitation, cyanosis feet and hands; paralysis of legs; genu internis, talipes valgus. Circumference of cranium 18″, cephalic index 76. Face asymmetrical; ears large; tonsils large; teeth good; palate high and arched.

2. Family History.— There were 4 siblings — 3 older and 1 younger than patient, one of which died of diphtheria. Other data lacking. Relatives and parents unknown. Patient a charge of Children's Institutions Department.

3. Personal and Developmental History.— First peculiarity is stated to have been noticed at 4 years, at which time patient was helpless, unable to talk, and untidy. His head was small, flat on the top and badly formed. There was no paralysis and it is stated that there have been no convulsions. Patient was slightly under-sized; hemiplegic (?). He is stated to have been very nervous, easily annoyed although not irritable; gluttonous; probably unable to recognize colors; patient was unable to grasp objects, but is stated to have been very destructive. Patient would lie in bed and make automatic movements. The cause for his deficiency is stated to have been meningitis at 6 months of age. Patient is stated to have had measles, whooping cough and erysipelas before coming to the School. Wassermann examination negative.

4, 5, 6 and 7. School Progress, School Examinations, Practical Knowledge, and Economic Efficiency.— All nil.

8. Social History and Reactions.— Good-tempered and happy but without interests.

9. Moral Reactions.— Nil. Patient occasionally had severe convulsions, becoming noisy before and after these attacks. There were some automatic movements. Six years before death patient had scarlet fever but made a good recovery.

10. Psychological Tests.— 1 year, Binet performed in 1914.

Waverley School History.— Patient died after convulsions Sept. 16, 1915.

b) Autopsy.

Body of a slenderly built, fairly nourished, white male, 128 cm. in length. *Skin* rosy grey in color. Few bruises over left leg.

Circumference of body at nipple line = 60 cm.
" " " " iliac level = 52 cm.
" " right wrist = 12.5 cm.
" " left " = 13.5 cm.

Some flattening in hypothenar eminence on right hand.

Body in right lateral decubitus.

Pupils contracted, measure 0.2 cm.

Ears somewhat outstanding, slightly unequal. Left reddened as is left side of face.

Teeth present. Good condition.

Genitalia.— Hair over pubis faint. Slight growth over mons. Prepuce long, forced back with difficulty. Considerable quantity of smegma over glans.

Left foot appears somewhat arched.

Ventral Section.— Fat over abdomen 0.4 cm., over chest 0.2 cm. Muscles red. *Peritoneum* grey and shining. *Intestines* distended, protrude over ventral section. *Omentum* scant in fat. *Transverse colon* at end of xiphoid process; lower part of liver and stomach concealed by it. *Spleen* small and free. *Appendix* lies in the pelvis, measures 12 cm. in length × 0.9 cm. in diameter. *Mesenteric lymph nodes* red, somewhat enlarged and very numerous. No free fluid in abdominal cavity. *Diaphragm* arches to 3rd rib on the right and on left.

Thorax.— Articulations between sternum and clavicle lax. Mammary vessels small. Some free fluid right pleural cavity, none in left. Lungs cover upper portion pericardial sac; thymus gland appears red and luxuriant covering pericardium to an extent of 6 × 5 × 1 cm. and extending down to cover a point overlying right auricle.

Heart.— Weight, 185 grams. Measures 8 × 7 cm. Epicardial fat scant. Descending branch left coronary negative; right negative.

Measurements: T. V. 7.0 cm. P. V. 5.0 cm. L.V. 0.6 cm.
M. V. 7.0 cm. A. V. 7.0 cm. R. V. 0.3 cm.

Aortic valve admits tip of finger. Endocardium greyish. Myocardium firm, greyish red in color.

Lungs.— Weight, 350 grams; right 410 grams. Right lung crepitant; lowest lobe blue. No scars. Bronchi bathed in red fluid. Section shows even congestion lowest lobe. Section floats. Left lung same description.

Organs of the Neck.— Tongue negative. Papillae at base of tongue prominent. Epiglottis small and prominent. Rima glottidis slender. At base of rima glottidis teat like projections curl forward and upward, giving a fish-tail appearance. Vocal cords relaxed, appear thread-like. Ventricle between true and false cords deep. Frothy mucus covers the trachea. Thyroid small. Thymus above described.

Abdomen.— Spleen. Weight 55 grams. Measures 9.5 × 6 × 2–0.4 cm. Capsule not thickened. Color reddish yellow. Section shows mottling of substance. No Malpighian bodies. No trabeculae seen.

Adrenals.— Show some central softening, otherwise not remarkable.

Kidneys.— Combined weight, 70 grams. Measurements, 9 × 4 × 2 cm., 9 × 4 × 1.5 cm. Capsule stringy, not thickened but strips with some difficulty. Cortex pinkish red, measures 0.4 cm. There are 4 pyramids. Pelvis enlarged, contains thin bloody fluid. Blood vessels negative. Other kidney contains 9 pyramids.

Liver.— Weight 565 grams. Measures 20 × 14 × 4 cm. Color reddish. Capsule somewhat thickened, inferior edge blunt. Section homogeneously red. Gall bladder contained no stones and a slight amount of thin brown fluid.

Gastro-Intestinal Tract.— Stomach injected. Duodenum negative. Colon negative.

Head.— Circumference 46 cm. Mento-occipital 40 cm. Inter-parietal 17 cm. Height of forehead frontal region 5 cm. Above left eyebrow, 1.8 cm. Above right eyebrow, 2 cm.

Brain.— 6 cm. posterior to the extreme frontal portion on the left is a depression 3 × 1 cm. Obliquely placed to the longitudinal section is a furrow 7 cm. in length running from the area represented as Broca to the point that would naturally be the precentral gyrus. The prefrontal area is indicated by the triangular area which points toward the olfactory lobes.

The *occipital lobes* are the only ones which appear to be approaching the normal in formation.

Brain substance soft. Some fluid at base.

Brain weighs 950 grams. Tigges' formula 8×128: 1024 grams. Loss of 74 grams in weight.

At the base of the brain the temporal tips approach leaving a space only 1 cm. in extent. The right temporal tip is broader than the left. The convolutions at the base are well marked.

Frontal poles are noticeably pointed and measure only 3 cm. in width. Gyri recti are both prominent and show a depth of measurement 1.5 cm. on the left, 1.8 cm. on the right, left being smoother.

Olfactory bulbs are edematous, optic nerves also.

Third nerves are buried in a slight thickening of pia mater.

Vertebral arteries smooth as is the basilar. No abnormalities of the formation of the circle of Willis. Pons and cerebellum soft.

Base of skull. Orbital plates of the frontal bone reach upward markedly. Middle clinoid processes are very short. Posterior clinoids broad, measure 2 cm. There is a slight bulging posteriorly of the body of the clinoid. Pituitary body measures 1.2×0.8 cm. Difference between lobes marked.

Gasserian ganglia small.

Middle ears negative.

Optic nerves negative.

Spinal cord soft — bulges at every cut.

General Appearance and Anomalies.

Fairly nourished.
Bruises legs.
Right lateral decubitus.
Pupils contracted.
Pubic hair scant.
Long prepuce
Appendix long.
Ears unequal.
Unequal hypothenar eminences.
Thymus persistent.
Rima glottidis malformed.
Vocal cords small.
Anomaly kidney.
Microcephalic.
Macrogyri.

Acute Lesions.

Pulmonary congestion.

Chronic Lesions.

Fibrous endocarditis.
Pulmonary congestion.
Atrophy liver.

c) Special Anatomical Description of Brain.

The photographs of this unique specimen speak for themselves with regard to the macrogyria which affects most markedly the entire superior surface of the brain and the region anterior and superior to the fissures of Sylvius upon the flanks. The observer cannot resist thinking of the resemblance of this brain to loaves of bread. The identification of sulci is a matter of some doubt. Apparently, however, the superior, middle and inferior frontal subdivisions of the frontal lobes are sufficiently well marked. Upon the left side the gyrus rectus seems unusually large and in fact the most plainly marked sulcus on the left orbital surface lies presumably far exterior to the locus of the furrow that normally demarcates the gyrus rectus.

d) Microscopic Examination.

If we examine a section from the left upper precentral region, for example, we shall find a very wide subpial layer containing many neuroglia cells with a rather dense fibrillar gliosis, but underneath the subpial zone we shall find the cortex extends nearly the entire depth of the section with hardly any signs of limitation and hardly any differentiation of the cells from one another in point of size. There are two lines of Betz cells; the one placed at some distance, the other Betz cells themselves containing little or no Nissl substance. Most of the other nerve cells in the tissues seem smaller than normal and pale without differentiation of Nissl substance. Their nuclei stained rather deeply and densely. There was a moderate increase of neuroglia and satellite cells throughout the section. Rod cells were also frequent. There was no evidence of perivascular exudate either in this section or any other section.

A section taken from the left postcentral gyrus begins to show some attempt at lamination but the lamination is still very incomplete. In this section as in a section from the posterior two thirds of the left first temporal gyrus the nerve cells are scattered without regard to form.

Passing back to the superior parietal area a fairly distinct lamination begins to be evident though still widely varying from the normal. Cortical cells are still found far down in the white matter, even the left superior parietal area shows scarcity of nerve cells and abnormal width of cortex although it yields a lamination more distinct than elsewhere.

The sections upon the right side show slightly better attempts at lamination but on the whole approximate the findings on the left side of the brain.

With respect to the cerebellum it was noteworthy that there was no suggestion of Vignal's layer nor was the cerebellum very remarkable. Purkinje cells were numerous but their nuclei stained deeply and densely much as the nerve cells in the cerebrum did.

This case deserves the most extended study. For the present purpose we report only a few of the more striking appearances in the sections already made.

In the macroscopical examination of the whole brain sections in this case, one is forcibly struck with the great thickness of the cortex throughout. The small number of convolutions and simon-simple brain pattern, which makes for a greatly contracted cortex area, seems to be compensated for in a way by this extreme thickness. This condition prevails especially over the convexities and internal surfaces, and to a lesser degree on the base of the brain where the convolutional pattern is much more complex and begins to approach the normal: the latter more normal structural picture is found especially in the regions of special sense, such as temporal, cuneate, and pyriform lobes. The cortex is also thin and more reduplicated in the gyri recti. By actual measurement the cortex in the simpler areas varies from 6 mm. to 13 mm. In the more complex areas mentioned it varies from $2\frac{1}{2}$–3–4.5 mm.

The ratio of white to grey matter is therefore not so greatly disturbed as it would seem on cursory examination; on the whole, however, the white matter suffers at the expense of the thick cortex.

Through the frontal lobes anterior to the genu of the corpus callosum, the cortex is enormously thickened, especially on the top and outer aspects. The white matter is pierced by small vessels and shows no degeneration. At the level of the genu they are dilated measuring variously from 1 mm. to 5–7 mm. In the temporal region this condition in unilateral. The fibres of the internal capsule in this region seem to be fewer than normal. There is beginning formation of the gyrus cingulus.

In the mid-callosal level the white matter is likewise proportionately reduced, which condition corresponds with the smaller and more or less ill-defined fibre bundles of the internal capsule. The perivascular spaces are also slightly dilated in the level of the splenium.

In the occipital region the appearance resembles the frontal. There is again greater preponderance of grey matter on top and laterally. Internally and at the base the cortex is thinner and here the white matter asserts itself. The ventricles appear normal in size. The ependymal lining, however, is slightly thickened generally. In the cerebellum the grey matter seems unevenly distributed on the two sides.

This striking case of macrogyria (the " loaf-of-bread " brain) presents problems of its own. The greatest problem no doubt is the cause of the failure of sulcation to develop over the whole top and fore parts of the brain, while at the same time no proper layering was going on inside the brain substance. Now this poor furrowing outside and poor layering inside go hand in hand: as one passes backward and beneath zones of more normal furrowing, one comes upon much better layering, until in the occipital poles there is, if not a normal, then a somewhat familiar looking lamination. Another pretty problem here is the relation of a fairly well developed corpus callosum to an otherwise poorly developed brain. In general, with this brain, we are evidently dealing with some mortific agent or some development-arresting agent, operating in the embryonic life and paying heed not so much to architectural details as to certain major trends on the part of the brain. Which is primary, the flaw in the furrowing process or some hypoplasia of lamination?

e) Anatomical and Histological Summary.

The brain of this fourteen year old idiot weighed but 950 grams and showed a remarkable condition of macrogyria. Without showing any evidence whatever of chronic inflammation there was nevertheless marked evidence of rod cell formation in this brain. The difficulty is clearly not hardly one of nerve cell aplasia though no doubt the bulk of the effects are due to some form of aplasia supervening in the embryonic life. The comparatively good preservation of the corpus callosum is a matter of remark.

Synopsis of Findings, Case XVII.

a) Clinical.

1. Physical Examination.— A. E. Ken., female, born Oct. 17, 1883, was admitted Sept. 13, 1911 and died Oct. 13, 1915. In February, 1914, patient was 5′ 1¼″ tall, weighed 118 pounds, was well developed and nourished, round-shouldered, myopic. Abdomen prominent, patellar reflexes exaggerated. Cranium circumference 21″, cephalic index 78. Slight beard, face asymmetrical, several front teeth missing, tongue fissured, high arched palate.

2. Family History.— Mother was 19 years of age and father 25 at birth of patient; father was killed by a fall from staging at 31. Pregnancy normal. Father's family stated to have been not brilliant but happy-go-lucky, phlegmatic and rather peculiar. Five of the mother's family, also maternal grandfather and grandmother died of tuberculosis.

3. Personal and Developmental History.— Patient is stated to have irregular monthly periods, to have been always slow in speech and motions and more so after twelve years of age. Patient was inclined to be gluttonous. Stated to have fallen several feet, striking on her head at the age of twelve.

4. History of School Progress.— At the School learned to read and write and to write her own letters, also to do simple number work.

5. School Examinations.— Nil.

6. Practical Knowledge.— Patient had lived in a family who had taken care of her although not related to her.

7. Economic Efficiency.— Did housework for this family. Was a laundry worker at School, although slow in movements, but very steady worker.

8. Social History and Reactions.— Patient got on well with other girls, made no friends, kept by herself, seemed to like to sit and watch others.

9. Moral Reactions.— Disposition good.

10. Psychological Tests.— 7. Binet performed in 1914.

Waverley School History.— Patient steadily retrograded after admission; although at first tidy in personal habits, patient at one time became untidy, later improved in this respect. Began to lose weight and strength in the last year of life; had an attack of furunculosis and 9 months before death had a severe convulsion after which she was dazed and could not walk well for some time. In February, 1915, patient had two severe convulsions, falling and bruising her forehead. After these convulsions patient was dazed for days, did not recognize people about her, talked and muttered incoherently, was untidy. In March occurred an attack of dysentery from which she recovered but kept steadily losing in weight. Patient died Oct. 13, 1915.

b) Autopsy.

Body of a well built and nourished white female, 160 cm. in length. Skin yellowish grey in color except for post mortem lividity over posterior neck regions and in dependent portions. Skin is soft and elastic. Faint yellowing of skin over forehead at hair line which follows hair line to ears.

Hair grows over forearms, slightly over breasts, abundantly over upper lip, chin and upper third of lower legs. Marked curling of hair over pubis.

No *edema*. No *decubitus*. Rigor mortis present. Umbilicus contains cerumen.

Pupils: right measures 0.6 cm., circular and regular; left measures 0.6 cm., is slightly irregular in outline.

Ventral Section.— Fat yellow and moist. Some increase of interstitial tissue; measures 3.0 cm., over abdomen: 2.5 cm. over thorax. Muscles of chest and abdominal wall red. *Peritoneum* grey. *Costal angle* broad. *Lower border of liver* 9.0 cm., *stomach* 13.0 cm., *transverse colon* 20.0 cm. below ensiform. Free edge of omentum markedly injected, otherwise scant in fat. Spleen large and free. Appendix injected at proximal portion; measures 7.0 cm. in length, also injected at tip. No free fluid in peritoneal cavity. *Mesenteric lymph nodes* prominent, somewhat enlarged, especially coecal group. *Bladder* contracted. Uterus markedly reddened on posterior surface, as is left fallopian tube. Left ovary plump, slightly more so than right. *Diaphragm* arches to the 3rd rib on the right, 4th on the left.

Thorax.— Fluid escapes on opening right thoracic cavity. This fluid is yellowish and free from blood tingeing. On opening left pleuric cavity, small amount of blood is present but is turbid and yellow. *Mammary vessels* collapse on section. Anterior mediastinum filled with fat. Lungs voluminous, almost meet in median line. *Right lung* adherent to pericardial sac at outer surface. Outside of pericardial sac congested, inside contains an excess of pale fluid. Right lung is adherent to the chest wall over the 2nd and 3rd ribs anteriorly.

Heart.— Weight, 195 grams. Measures 9 × 8 cm. Epicardial fat abundant. Descending branch of left coronary smooth; right collapses on section and walls are delicate.

Measurements: T. V. 11.0 cm. P. V. 5.0 cm. L. V. 0.8 cm.
M. V. 8.0 cm. A. V. 6.0 cm. R. V. 0.4 cm.

The free edge of the tricuspid valve is slightly thickened. Cusps of the pulmonary valve unequal in size. The *endocardium* slightly grey near valves but is not involved at apex. Superior edge of one aortic leaflet slightly puckered. Myocardium red and firm.

Lungs.— Weight, left 1075 grams, right 1035 grams. Right lung, upper lobe, soft, greyish white; middle lobe adherent to chest wall; lateral border of middle and posterior border of lowest deep red. Section shows mottled red and grey lung tissue; reddish areas surround grey ones which in turn are localized around the bronchi. An odor suggesting the breaking down of lung tissue accompanies this. Fibrin can be expressed from some of the bronchi in the middle lobe. A smear shows pus cells. No Gram + organisms. A few Gram negative bacilli. No tubercle bacilli. Bronchi bathed in blood. *Left lung*: upper lobe free; lower lobe blackish red in color superficially. Section duplicates description of other lung.

Organs of Neck.— Not removed.

Abdomen.— Spleen. Weight, 170 grams. Measures 13 × 8 × 2 cm. One fetal lobulation extends for 7.0 cm. across the superior surface. Capsule pinkish blue in color. Section shows pulp firm and red, otherwise negative. Malpighian bodies not present. Trabeculae slightly increased.

Adrenals.— Large and plump; show some central softening.

Kidneys.— Weight, 170 grams. Measure 10 × 5 × 2 cm. and 9.5 × 5.5 × 2 cm. Capsule thin, strips easily. Cortex measures 0.6 cm., is greyish with brilliant injection and granular surface. Six pyramids all deeply red. Pelvis negative. Other kidney shows same description.

Liver.— Weight, 1475 grams. Measures 25 × 18 × 6 cm. Inferior edge of liver fairly blunt. Capsule slightly thickened. Color reddish, slightly mottled by yellow. Section shows nothing of note. Gall bladder contains no stones but has slightly granular brownish fluid.

Pancreas.— Thin but shows no abnormalities on section. Splenic artery slightly thickened.

Gastro-Intestinal Tract.— Esophagus not notable. Stomach small, yellowish white in color. There are pinhead to pinpoint nodules in the mucosa of the stomach wall surrounding the esophageal opening in the stomach. *Lesser curvature* shows some submucous hemorrhages with isolated black dots (? indicating former hemorrhages). Pyloric opening small, otherwise not notable. *Duodenal content* pale with markedly granular appearance to mucosa. *Jejunum* negative. *Upper ileum* shows spots of congestion and wall somewhat thickened, especially in lower portion. About 9.0 cm. above ileocecal valve there is induration and injection of a single Peyer's patch. This has a slightly " shaven beard " appearance with the addition of punctate raised and deeply reddened surface. Immediately above the ileo-cecal valve, the Peyer's patches are markedly enlarged and reddened and here and there are beginning ulcer formation. These are minute, measuring not more than 0.2 cm., are fiery red; edges somewhat raised. *A smear* from the center of these shows by Gram disintegrated cells, Gram negative plump bacilli and Gram + cocci. By Ziehl Neilsen, no tubercle bacilli.

In the mucosa of the cecum there are clusters of raised yellow ? reddish areas which spread slightly, not unlike herpes. There are *solitary ulcers* on the summits of the rugae which are small, fiery red, as are the ones which surround the Peyer's patches in the ileum. These solitary ulcers dot the ascending and transverse colon but do not extend into the descending colon. Rectum free.

Genito-Urinary Tract.— Bladder somewhat injected. Vaginal mucosa wrinkled. Uterus shows some free blood in the interior. Ovaries show some appearance of functioning.

Retro-Peritoneal Tissues.— The aorta is smooth. Small ulcers show some faint, raised yellow plaques about the origin of branches. The lymph nodes along the aorta are somewhat redder than usual. Culture taken. Peripheral and sympathetic nerves show nothing on inspection.

Head.— *Hair* brown and abundant. *Scalp* not remarkable.

Calvarium measures frontal, 0.5 cm., temporal 0.3 cm., occipital 0.6 cm.

Dura mater not adherent, is slightly thickened over vertex and in the middle meningeal distribution.

Pia mater is thin and delicate except along the vessels over the vertex; here it is slightly cloudy. There is an abundant collection of clear fluid over the parietal and motor regions. The hemispheres appear equal.

Convolutions exceedingly complex. The tips of the occipital pole markedly smaller than normal and there appears to be an anomaly of the left parietal lobule inasmuch as it appears to encroach upon the superior portion of the occipital lobe. This is more marked on the left than on the right. The left second temporal markedly interrupted by crisscrossing of gyri running at different angles than usual.

Base of Brain.— Cranial nerves show nothing of note. Basal vessels small, somewhat white.

Slight granularity of pia mater at the base, smear from which shows red blood cells and endothelial and connective tissue cells. There is no increase of consistency palpable at base. Superior surfaces show a general increase.

The right Gasserian ganglion is edematous. Pituitary fairly well exposed. On section the pituitary appears yellow in its posterior portion (? former hemorrhage). Ear drums negative.

Brain weight, 1375 grams. Tigges' formula 8 × 160: 1280 grams. Gain of 95 grams.

General Appearance and Anomalies.

Well nourished.
Pupils dilated, one irregular.
Anomalies: aortic leaflet.
parietals.
occipitals.
Gasserian ganglia.

Acute Lesions.

Bronchopneumonia.
Hemorrhagic bronchitis.
Cardiac dilatation.
Ulcerative ileitis and colitis.
Endometritis.
Parenchymatous nephritis.
Hemorrhagic pituitary.
Lymph loops in gastric mucosa.

Chronic Lesions.

Hydrothorax.
Fibrous pericarditis.
Hydropericardium.
Fibrous endocarditis ventricular.
Splanchnoptosis.
Atrophy spleen.
Dura thick.
Leptomeningitis.
Subpial edema.
Brain wt. 1375.

c) Special Anatomical Description of Brain.

The complexity of the convolutional pattern is noteworthy in this brain. The tips of the occipital poles appear to be smaller than normal and there is also an anomaly in the appearance of the parietal areas. The pia-arachnoid was everywhere slightly cloudy and somewhat more adherent to the dura mater along the longitudinal fissure than is usual. There were also pial adhesions to the frontal lobes. There was a very fine granulation in the floor of the third ventricle and a suggestion of this in the fourth.

The summits of the gyri failed to lie always in the same plane and their borders were not always approximated. The tendency throughout this brain is to a point rather than to a flat tipping of the gyri and this acuminate tendency is especially well shown in the frontal and prefrontal areas. There was a slight thinning of the posterior third of the corpus callosum.

d) Microscopic Examination.

No perivascular exudate was to be found in most areas, yet about a single vessel in the left angular gyrus there was a focus of small round cells of the exudative group and in the left superior frontal gyrus there were focal groups of small round cells of the lymphatic group. There were nowhere any plasma cells.

The blood vessels were not anywhere remarkable.

There were moderately slight increases of neuroglia cells in the outer layers in many areas, some-

times this glia cell increase was more focal than general. The white matter also showed a slight or moderately general glia cell increase.

The nerve cells showed some acute changes (axon reactions and simple chromatolysis). Many areas showed no thinning out of the nerve cells but other areas showed focal thinnings out of cells well distributed through the cortex. In some areas (e. g. left superior temporal) the falling out of cells was more marked in the supragranular layers. In some places the thinning of the cells was more marked over the crowns of the gyri than upon their sides (left angular gyrus). There were in many areas increases in numbers of the satellite cells about the nerve cells.

The general relationship between the white and grey matter appears normal. There are no gross fiber tract degenerations; the white matter throughout firmly takes the Weigert stain. There are no gross morphological changes. The ventricles are not dilated. The occipito-frontal fascicle is shown in faint outline and the subependymal grey matter is plainly visible. The internal capsule is well defined as is also the external capsule. The optic tracts are sharply outlined. The external and internal lamina of the lenticular nucleus are distinct. The ependyma is slightly thickened posteriorly.

The cerebellum showed in some areas a noticeable scarcity of Purkinje cells. In other areas there appeared to be a normal quantity of Purkinje cells but their arrangement was scattered.

e) Anatomical and Histological Summary.

The brain of this thirty-one year old imbecile was of good weight (1275 grams). On the whole, although there are a few evidences of chronic imflammation in this brain the rest of the histological picture seems to bear slight relation to the lymphocytosis (no evidence of plasmocytosis). The situation appears to be one of a somewhat irregular though general tendency to aplasia of the gyri in the manner termed " pointing." There was no evidence of nerve cells in the white substance nor any special tendency to heterotopia of cells except in some parts of the cerebellum.

Synopsis of Findings, Case XVIII.

a) Clinical.

1. Physical Examination.— D. Ric., male, born May 2, 1906, admitted Jan. 18, 1912 and died Nov. 9, 1915. July 28, 1913, patient at 7 years was 3′ 9″ tall and weighed 43¼ lbs.; was poorly developed and nourished, had chronic bronchitis, had dry coarse skin, thin, coarse, wiry hair and heart with systolic murmur at apex; infantile genitalia; umbilical hernia; protruding abdomen; poorly developed muscles; thick hands, short, stubby fingers; cranium circumference 23″, cephalic index 80.77; bulging forehead; asymmetrical face, large protruding ears; chronic discharge of nose; tonsils enlarged, adenoids; fissured tongue. It was a question whether patient was a cretinoid idiot.

2. Family History.— There were six children of which patient was the second. The first three children resembled each other somewhat closely and all died at the Massachusetts School for Feebleminded. Three later children were normal, one dying young of diphtheria. The mother is said to have been emotionally disturbed during pregnancy; patient's father was 26 years of age at patient's birth. A paternal aunt became blind in later years; an uncle and sister of the patient had spinal trouble; the sister in question became partially blind; there was a feeble-minded and epileptic great-aunt.

A special study of the heredity was made by Miss E. C. Macomber. It is stated that abortions were attempted with drugs in the early months of pregnancy in each of the three feebleminded; the three children lived as follows: first 1905–1912; second (patient) 1906–1915; third, 1907–1912. The

sister born three years later is not feeble-minded and a child born years after this sister, prematurely, died at one year old. Two children followed: the three living children are said to be normal. The mother has two competent sisters, a sister migrainous and obese whose one living child has one arm not fully developed. Five other siblings of patient's mother died young. Both patient's mother and maternal grandmother are stated to have been nervous, and patient's grandmother also migrainous.

The siblings on the father's side are apparently normal, middle-class persons, except one who was alcoholic and tuberculous and another was deformed, with spinal curvature. There is an epileptic and feeble-minded great-aunt, a lame great-uncle and a blind great-aunt.

3. Personal and Developmental History.— Patient began to talk at about a year and to walk alone at 19 months. Peculiarities were first noted on 2 years. Patient had peculiarity in speech, using " D " for the first letter. Was able to help in dressing and undressing himself and to feed himself with a spoon or fork.

4, 5, 6, 7, and 8. School Progress, School Examination, Practical Knowledge, and Economic Efficiency.— All nil.

8. Social History and Reactions.— Patient was stubborn, irritable, running about in his own way, screaming when touched to be dressed or undressed, spitting on the floor and screaming if he did not wish to be moved; would not eat if any one was looking at him; had lost capacity to feed himself, throwing food about. Patient loved dress and was fond of pretty neckties. If given a toy would go by himself to play with it, screaming if another child went near him. If candy was being distributed, patient would join the crowd of boys surrounding the donor and stretch his hands up for some. Patient said " No " to almost everyone. Patient was rough with other children, throwing anything he had in his hands. He would smile at people he liked but was not affectionate and did not wish to be petted. He recognized the people who took care of him and was not shy with them.

9. Moral reactions.— (See social reactions). Patient would cry a good deal and pounded his head on the back of settees; he had a habit of putting his hands over his face and peeking through his fingers as if bashful.

10. Psychological Test.— 1.0 Binet performed May 11, 1914.

Waverley School History.— Patient required nursery care; was in the hospital and infirmary most of the time, with habits untidy day and night. Patient had frequent illnesses, chicken pox, measles, bronchitis, indigestion, grew thin and developed a cough, Nov. 4, 1915; had slight unilateral convulsion with twitching of right side of face; spasmodic opening and shutting of mouth; there was for a time severe dyspnoea with mucus in throat and weak pulse; after vomiting patient seemed slightly relieved. Patient gave an impression of meningitis, remained comatose; Nov. 5th had developed bedsores on back of his head and on hip; and could at this time swallow with difficulty. Nov. 8th was unconscious with slight paralysis of right side of face; right eye open with sloughing of right cornea; death Nov. 9, 1915.

b) Autopsy.

Body of a slenderly built, poorly nourished white male, 115 cm. in length, in left lateral decubitus, four hours post mortem. Skin rosy grey in color. Small *decubitus* over left trochanter major measures 2×2 cm. in diameter. Slight bluish *discoloration* over right trochanter. Abrasions over tip of the nose and lower lip measure 1.1 and 1.2 cm. Two abrasions on knees co-incident at point of pressure.

Hair shows faint growth over abdomen and chest, over forearms and upper arms; none over pubis, abundant over neck and back; growth in multiple cowlic over head. Suggestion of bowing of right radius in lower third; same on left. No roughening of tibia.

No palpable lymph nodes except left inguinal region.

Penis small. Prepuce redundant. Testes descended. No edema.

Flattening of thenar and hyperthenar eminences. Right hand measures 6.5 cm. over knuckles; left same. Greatest length, 13.0 cm. Snuff box deep.

Pupils — right 0.6 cm., left 0.4 cm. Suggestion of bruising of right eyelid. Eyeballs firm. Conjunctiva over right cornea denuded (2 days in duration).

Hair rough and short but fairly abundant. Two abraded areas on occipital portion measure 2 and 1 cm. in diameter. Circumference of head 58.8 cm., mento-occipital 47 cm., mento-bragmatic 10 cm., mastoid to mastoid 38 cm.

Nose short and broad (saddle).

Teeth — two middle incisors upper, highly placed, not in line with the first teeth. Four central incisors in lower jaw.

Ears somewhat thick through, lobules not adherent, measure 6 cm. and 5.5 cm. in length.

Circumference of chest at costal margin 53.0 cm.

Rigor mortis present.

Ventral Section.— Fat over chest and abdomen scant. *Muscles* yellowish red. *Peritoneum* grey. *Costal angle* medium. *Lower border of liver* 6.0 cm., *transverse colon* 15.0 cm. below ensiform. *Omentum* scant. *Transverse colon* in "S" shaped arrangement covers stomach. *Spleen* — small adhesions external surface. *Appendix* coiled upon itself. *Mesentery* to tip, measures 10.0 cm. *Mesenteric lymph nodes* prominent, numerous, and vary from 0.5 to 1.5 × 1.5 cm. No free blood in peritoneal cavity. *Diaphragm* arches to the 3rd rib on right and 3d rib on left.

Thorax.— Pleura free from fluid and adhesions. Lungs meet in upper third of their free edges. *Pericardial sac* red. No excess of fluid; that which is present is clear yellow in color. (Phenomenon of post mortem auricular contraction present 4 hrs. P. M.) after removal of brain.

Heart.— Weight, 85 grams. Pericardium smooth and shining. Appendage free from clot; wall 0.3 cm. Muscle pale. Right auricular endocardium smooth and shining.

Measurements: T. V. 8.0 cm. P. V. 4.2 cm. L. V. 2.0 cm.
M. V. 6.5 cm. A. V. 4.0 cm. R. V. 0.4 cm.

Tricuspid valve cusps markedly thickened, irregular and saw-toothed, without marked calcification; admits little finger. Right ventricle muscle pale. Chordae tendinae and papillary muscles appear normal. Pulmonary valve cusps not thickened, appear normal. Pulmonary artery shows no pathological change. Left auricle — wall 2.0 cm. *Endocardium* smooth and shining. Ventricular cavity appears slightly enlarged. Mitral valve opening about 2.0 cm. in diameter. Valve cusps are greatly thickened, contracted but not markedly calcified. Chordae tendinae appear normal. Papillary muscles hypertrophied. Left ventricle is of good color. Valve cusps slightly thickened and stiff, otherwise not remarkable. Ascending portion of aorta smooth without pathological change. Coronaries appear normal.

Lungs.— Weight, right lung, 110 grams; left lung 95 grams. Visceral pleura smooth and shining. Bronchus and bronchioles show no pathological change. No pus. Slight amount of hypostatic congestion lower lobe. On cut section surface appears rather dry. No pus is exuded on pressure. No tubercles seen at any point.

Abdomen.— Spleen. Weight, 85 grams. Measures 10 × 6 × 2.5 cm. Dark bluish purple in color. Cut section is dark mahogany red in color. Pulp not increased. Slight amount of bloody fluid easily scraped off. Normal anatomical markings clearly seen. Small accessory spleen size of a pea on left, above.

Adrenals.— Show nothing of note.

Kidneys.— Weight, 85 grams. Normal in size and shape. Capsule strips easily. Kidney cuts with normal resistance. Cortex measures 0.5 cm. Pyramids pinkish in color, surrounded by dark rim.

Liver.— Weight, 680 grams. Color brownish, slightly mottled. Edges sharp. Capsule smooth, not thickened; everywhere normal in consistency. Cut section surface seems rather dry but otherwise

not remarkable. Gall bladder normal in size and position, walls not thickened and contains about 26 cc. of bile; normal in appearance.

Pancreas.— Shows nothing of note.

Gastro-Intestinal Tract.— Stomach small and contracted. Rugae present. Some bile stained material on wall. Nothing of note in tract. Excess of rectal length, 18.0 cm.

Genito-Urinary Tract.— Bladder small, prostate thin — (kept unopened for research for Dr. Rohde).

Retroperitoneal Tissues.— No change noted in sympathetic and peripheral nerves. Retroperitoneal lymph nodes somewhat enlarged, as are mesenteric, but not as numerous as the latter. Aorta elastic, smooth except for few dots of thickening near origin of vessels.

Head.— Calvarium measures 1.0 cm. median line, 0.5 cm. either side, temporal 1–0.7 cm., occipital 1.0 cm. Under surface of scalp shows bruise in vertex and over right frontal region; these measure 4×3 cm., 2×1.5 cm. and 5×2.5 cm. Periosteum negative. Temporal muscles poorly developed. Sutures prominent.

Superior Surface of the Brain.— Dura adherent to the calvarium in its entirety.

Pia mater cloudy over all portions except occipital and portions of the parietal lobes. Left side is more densely covered by thickened pia and ? new formation of membrane than the right.

Convolutional pattern is fairly rich. Rosette formations are frequent. Atrophy and gliosis everywhere present. This atrophy also apparent in the mesial portion. Slight indication of softening in the angular gyrus region. Some subpial hemorrhages over supramarginal region on the left.

Base of Brain.— Left hemisphere sags more than right and the base shows a marked asymmetry and irregularity. The left temporal lobe is markedly atrophic but contains more complex windings of gyri than the right. Left hemisphere measures approximately 18.0 cm., right 19.0+ cm. This shortening appears to be in the frontal pole, greatest distance from Sylvian fissure to the prefrontal pole on left being 4.5 cm., on right 6.0 cm. At the base of the olfactory bulbs the grey matter presents a hump measuring 3×1.5 cm. on the right, 4.4×1.5 cm. on the left median line.

In the orbital portion of the frontal pole there is marked depression on the left side, which is not so marked on the right. The first temporal convolutions measure 0.7 cm. on the right; appears to be hidden on the left. Convolutions at the tip measure 0.8 cm. on the right and 1.3 cm. on the left. Marked irregularities and atrophies on both temporal lobes. Lobus pyriformis prominent on the left, has a pyramidal appearance; right is circular; both firm, right more so than left. Entire base markedly firmer than normal.

Olfactory tract thin. Optic nerves small.

Circle of Willis is obscured by thickened pia mater. There appears to be no anomaly. The vertebrals are markedly irregular and unequal in size: left measures 1.0 mm. in width.

Fourth ventricle — granulations are present and ependyma appears gelatinous.

Mammillary bodies appear oval.

Pons medulla and cerebellum present nothing of note except rather firmer than normal.

Smear from base of brain by Ziehl-Neilsen stain shows no tubercle bacilli: by cresyl-violet shows an occasional polynuclear cell, otherwise cells are of uneven size of endothelial type.

Base of Skull.— The cribriform plate of the ethmoid is sunken to a depth of 1.3 cm. and measures 2.6 cm. in length $\times$ 2.0 cm. in width. The tips of the frontal lobes fit into this depression. The anterior fossa shows marked bulging upward to the orbital plates. The posterior clinoid processes measure 2.0 cm. in width. The middle clinoid 0.8 cm. The pituitary is well uncovered. Glandular portion of the pituitary is redder than usual. Nervous portion apparently somewhat pigmented (brown).

Pus wells out of the right middle ear, stained smear from which shows fatty infiltrated leucocytes and minute Gram positive bacilli.

Brain weight, 1475 grams. Tigges' formula 8×115: 920 grams. Gain in weight, 555 grams.

Physical Signs of Degeneracy.	*Vierordt's Table.*	
Length of child of ten years,	127.8	115
Size of head (circumference)	52.2	58.8 cm.

Saddle nose.
Bowing of radii.
Hair stubby and " wild growth " over head.
Excess of hair over neck and back.
Ears thick.
Teeth (late eruption of second teeth — high placing).
Hands show unusual form.
Bones unequal in size and thickness, skull.
Olfactory lobes prominent — (like a dog's brain).
Malformation of skull (anterior fossa).

Evidence of Syphilis.	*Against Syphilis.*
History significant.	Negative Wassermann reaction in serum post mortem.
Father's attitude significant.	Negative Gold sol reaction in all loci.
Chronic pachymeningitis.	Negative plasma cells in base of brain.
Chronic leptomeningitis.	
Cerebral atrophy.	
Cerebral gliosis.	
Spinal gliosis.	
Chronic endocarditis.	

General Appearance and Anomalies.

Poorly nourished.	Teeth uneven.
Left lateral decubitus.	Ears unequal.
Flat thenar and hypothenar eminences.	Redundant prepuce.
Bruise eyelid.	Penis small.
Abrasions head.	Postmorten cardiac contraction.
Nose short and broad.	Accessory spleen.
Ears thick.	Excess rectal length.
Bedsore, trochanteric.	Middle fossa change.
Pupils unequal.	Rosettes in brain pattern.
Hair abundant over neck.	Unequal temporals.
Hair grows in cowlic over head.	Unequal vertebrals.
Head large.	

Acute and Chronic Lesions.

Otitis media.	Fibrous endocarditis ventricular.
Subpial hemorrhages.	Pachymeningitis.
Bowing radii.	Leptomeningitis.
Lymphnoditis mesenteric, retroperitoneal.	Prominent olfactories.
Perisplenitis.	Atrophy temporals.
Fibrous endocarditis tricuspid.	Brain weight 1475.

c) Special Anatomical Description of Brain.

The meninges were edematous and there were some extensive adhesions between the dura mater and the pia mater, always a condition suggestive though not demonstrative of syphilis. The sulci were broad and even from the outside the brain showed evidence of atrophy. Noteworthy were a few lenticular cystic areas on the surface of the brain similar to vacuolated areas in the substances on section. Very remarkable was the preservation of the cortical tissues in areas immediately adjacent to cysts of the white matter. The basal ganglia area was in general not affected by such cyst-like lesions.

Professor W. T. Councilman of the Harvard Medical School took a great interest in this case on account of its partial resemblance to a previous case under his observation and we here embody a portion of Dr. Councilman's description.

From a case of Doctor Taft's. The case that of a boy 9 years of age, from an asylum for feeble-minded. Not sure, but probably syphilis. Arteries at base of brain normal. The meninges are oedematous; an area on the surface which consisted in a very great thickening of the meninges with seeming adhesions of dura at the point was possibly organization of exudate. This on one side.

The pia easily stripped. The cortex shows a general atrophy, sulci large, the atrophy in places showing definitely on the surface. The surface also showed a few lenticular-like nodules; the section of brain shows areas, apparent vacuoles, around all of the blood vessels of the cortical white matter. A general atrophy of the grey matter, this seemed unaffected, and the places so prominent in the white matter, adjacent to the cortex, did not show in the cortex. The basal ganglia were unaffected; no such lesions in the pons or medulla. The cord not examined. The lesions in this case present a striking similarity to the lesions which were observed in case H-15-73.

The brain as received has the hemispheres separated. The meninges have been removed from the right hemisphere. On the left hemisphere a block of tissue has been taken. The left hemisphere shows the meninges in general slightly thickened and somewhat opaque. The sulci are rather more apparent than usual. The thickening of the meninges most marked along the longitudinal fissure; and on the inner side, extending pretty well over the lateral surface of the frontal lobe, back to the posterior central convolution, down over the fissure of Sylvius, is an area 12×6 cm., extending anteriorly to within 2.0 cm. of the frontal edge of the brain. The meninges are very greatly thickened, and there seems to be a membrane which is adherent to the meninges beneath, which can be partially separated from them, which is slightly brownish. There are tags which show adhesions between this membrane, which is not dura, and what is probably the dura above. One cannot be absolutely sure however, that this is not an area of dura which was adherent to the inner meninges, and which has been cut off. All the ventricles of the brain are very greatly dilated, the dilatation being especially marked in the aqueduct. The meninges over the cerebellum, which have not been removed, are somewhat thickened and cloudy, and there is a well marked cerebellar herniation into the foramen magnum. There is a wider space than usual between the lobes of the cerebellum. The ependyma of the dilated lateral ventricles seems cloudy and slightly granular. The right hemisphere shows on its mesial surface a very well marked atrophy of the convolutions. All convolutions share in this, but the atrophy seems particularly marked in the marginal convolution. At several points here the inner meninges clung on removal, and small areas of cortex were removed with them. The surface of the atrophied convolutions is not smooth, but greatly wrinkled, there being definite depressions at various points. There is no particular abnormality in the run of the convolutions. The atrophy is probably rather more marked in the entire frontal region of the brain than elsewhere, and projecting from the region here there are small flattened elevations from 1 to 2 mm. in width, projecting about $\frac{1}{4}$ mm. above the surface. They give the impression of small flattened discs directly placed on the surface. There are several of these, the largest of them being in the operculum, and in this immediate region there are five. On the surface of the parietal lobe there are similar areas, though smaller. There

is a peculiar appearance in the upper mesial edge of the first frontal convolution; the sulcus here is very wide, and there is the appearance as though the atrophy were very much more marked immediately below the surface than elsewhere. The least atrophy is in the occipital lobe. It is very well marked in the temporal lobe, especially in the first temporal convolution. It does not seem to have affected particularly the area of the Island of Reil, although it is evident to some degree in all parts of the brain. The arteries at the base of the brain are normal and over the cerebellum the depressions formed by the skull are extremely prevalent. This case will be further studied in the sections which will be obtained from Doctor Taft. It is especially interesting in relation to the extreme dilatation of the ventricles, because this would seem to be due possibly in part to the contraction of the brain, a dilatation ex-vacuole, and also partly to the chronic meningitis interfering with the excretion of the cerebrospinal fluid.

A section of this brain which was given me by Doctor Canavan shows a very great thickening of the meninges, the section being taken from the area of thickening, and this shows that the thickened mass is not dura. It contains on its surface, and near the surface, a lot of very black blood pigment, from formalin hardening, and the membrane itself is formed of very dense bands of connective tissue, with wide spaces between. The surface of the brain is very oedematous. There is very marked granular disintegration of all of the pyramidal cells, without any Nissl bodies, the cells being simply filled with granules. The most prominent thing in the section, however, is seen in the peri-vascular spaces, which are enormously dilated, and which, unlike a previous case, contain a considerable amount of tissue within them which is attached to the vessels, and around the margin of the peri-vascular spaces there is very marked gliosis. All this will be studied further.

d) Microscopical Examination.

The cortex from various regions, stained with Haematoxylin and eosin, phosphotungstic haematoxylin, and Cresyl-violet. There is not a sharply defined marginal gliosis. The sub-marginal layer is oedematous, and contains numbers of glia cells, usually stellate, but there is not an abundant formation of fibrils. Blood vessels of the grey matter generally are injected, abundant. There is, however, in the grey matter, no marked dilatation of peri-vascular spaces. About some of the larger vessels however, there seems to be some tendency towards this. In the grey matter in most areas there does not seem to be any increase in the glia cells save in a layer immediately below the margin. In the upper layers of the grey matter occasionally spider cells are found. There is a great deal of degeneration in the nerve cells. The large pyramidal cells are relatively in the best condition. The other cells have pale protoplasm, which is sometimes glassy, and have a marked increase in granules, but the Nissl bodies are not apparent. The nuclei generally are present at one end of the cell, often protruding from the contour. There is a sharp change, however, in the white matter, and the most marked thing here is the dilatation of the peri-vascular spaces, which is nearly universal, but much more accentuated in certain places. In these peri-vascular spaces generally the vessel lies in the center of the space, supported by a thin mesh-work of tissue which is not neuroglia, but represents apparently a growth of tissue coming from the vessels. It is very loose in its general character, and in places seems to consist chiefly of cells which are connected together by their processes, forming a very delicate network. Around the margin there is an increase of neuroglia, and neuroglia fibrils to some extent project into the tissue. In this loose net-work compound granule cells are found. In places the net-work does not extend all over the space. It has apparently been pulled from the margin of attachment. In other places in place of the net-work there is a definite tissue, seemingly of connective tissue origin, and in many of the spaces the compound granule cells are much more abundant. There is a great deal of variation in the degree of ganglion cell degeneration; in places extremely marked, and in all cases the pyramidal cells are the least affected. The process as studied here seems to be in its general features very similar to the conditions seen in the case of syphilis of the brain,

and to be brought about by the action of a substance which primarily leads to an injury in the white matter of the brain, making itself apparent chiefly in the region around the vessels. The process here, however, would not seem to be so advanced as in the other case of cerebral syphilis, this being apparent in the presence of the compound granule cells, indicating a continuation of the process of disintegration.

The gross Weigert sections show an extensive hydrocephalus which reaches a higher degree in the posterior and lower cornua of the lateral ventricles. It is slightly greater on the left side, the anterior limit of the lateral ventricle here extending farther front. In general on this side the various tracts and nuclei such as the internal and external capsule, the caudate nucleus and the corpus striatum are smaller. The normal proportion of white matter to grey is disturbed in favor of the latter in the periphery more posteriorly by the numerous perivascular dilatations and in the deeper regions of the brain by the pressure of the hydrocephalus.

Throughout the white matter there is a marked degree of perivascular dilatation: this consists of an enlargement of the spaces about the vessels in which the vessel itself appears small in comparison usually placed somewhere near the center of the space and surrounded by varying amounts of a loose cellular tissue (Fig. XVIII, u, v, w). These vascular dilatations are more numerous and larger in the middle and posterior parts of the brain. At the level of the posterior part of the optic thalamus the white matter is almost riddled by these dilated spaces, forming only a connecting network around them.

d) Microscopical Summary.

Considerable subpial gliosis.

Larger cells swollen at base — nucleus pushed toward apex.

Much general glia cell increase especially in white substance, including amyloid forms — occasionally rod cells.

Perivascular spaces in white substance much enlarged and filled with loose meshed connective tissue in which are frequent compound granule cells and a few small round cells with an occasional plasma-like cell. Sometimes several small vessels in the space. No perivascular change in grey matter. Capillaries numerous and prominent everywhere. Marchi shows moderate reaction in posterior columns of cervical spinal cord. None in cortex.

The tracts show no degeneration by the Weigert method. The white matter besides being considerably compressed by the hydrocephalus, is riddled by the cystic dilatations of the perivascular spaces, mentioned elsewhere.

e) Anatomical and Histological Summary.

Subsequent to the autopsy and microscopic examination of this case a further investigation of the family condition was made by Dr. Walter E. Fernald. There seems to be no doubt of the syphilitic nature of the condition even from the clinical standpoint as a competent physician was found who had treated the father for this condition.

The brain weighed 1475 grams, a gain of over 500 grams over an estimated weight by Tigges' formula. The child had several external anomalies; high placed teeth, unusual thickness of bones, 'wild' hair, malformation of skull and brain.

The membranes of the brain markedly thickened suggested on inspection an advanced meningo-encephalitis. The gross sections showed a marked cystic state of the white matter, and a hydrocephalus. The microscopical examination shows cystic space about vessels and palm leaf-shaped nerve cells with collection of stainable protoplasm at their major axon.

U. Low power view of section showing cystic degeneration.

V, W. High power view. Note ingrowth of peculiar cells about vessels running through cysts. (See description, Case XVIII, under item d.)

Synopsis of Findings, Case XIX.

a) Clinical.

1. Physical Examination.— R. Hal., male, born Sept. 28, 1892, admitted Feb. 1, 1912, and died Dec. 4, 1915. Feb. 2, 1915, patient at the age of 21 weighed 112 lbs., was 5′ 3½″ tall, well developed and nourished, with horny materials upon the soles of the feet and over the knees. Hands hard and horny. Ulcerations over each tibia. Cranium circumference 19¼″, cephalic index 73.52. Face characteristically Mongolian, asymmetrical, small, well-shaped ears; tonsils enlarged, several teeth missing, some decayed, transverse fissure of tongue. Wassermann reaction had been negative December 1914.

2. Family History.— Patient's father was 25 years of age and mother 22 when patient was born. Patient the elder of two children; delivery difficult; instrumental.[1]

3. Personal and Developmental History.— Patient walked at one and a half years, talked at two years; had scarlet fever, measles and chicken pox before admission. For a Mongolian, health at institution exceptionally good. Moist eczema of both legs; this was relieved by institutional care, but had returned after patient's return home. Patient had been admitted to the school for the first time on July 7, 1904, at 11 years, being at that time a bright-looking boy, able to talk. After four years of sense and hand training, patient could do most of the exercises. He was taken out by his family in 1909 and failed considerably before re-admission in 1912, having grown thinner and less alert.

4 and 5. School Progress and Examinations.— See above.

6 and 7. Practical Knowledge and Economic Efficiency.— Nil.

8. Social History and Reactions.— Not very talkative unless spoken to, but then would talk a good deal. Habits tidy, easily interested in things about him; liked to play games; was able to read a few words.

9. Moral Reactions.— Quiet; inoffensive.

10. Psychological Tests.— 5.2 Binet performed Aug. 13, 1914.

Waverley School History.— Transferred to Templeton Colony, patient improved mentally and physically, gaining in weight and becoming more alert. After being brought back to Waverley, in Dec. 1914, eczema grew worse but was cleared up under arsenic treatment. Patient died of typhoid fever Dec. 4, 1915.

b) Autopsy.

Body of a slender, fairly well nourished white male, 160 cm. in length. *Skin* red in blotches over abdomen, brown scales over knees. Shins thick and leathery, brown in color. In center of thickened areas occur eroded areas measuring 5 × 2 cm., 3 × 2 cm., 3 × 4 cm. No edema, no palpable lymph nodes.

Circumference of head, 48.0 cm., mento occipital 36.0 cm. Interparietal not taken.

Ventral Section.— Fat over abdomen 0.8 cm., over chest 0.5 cm. *Muscles* deep red except near

[1] An elaborate study of the family history was made by Miss E. C. Macomber. The chart shows three examples of feeble-mindedness in patient's fraternity, and three in the parental fraternity; there are three instances of cancer in the parental fraternity and two in the grandparental fraternity, and one in the great-grandparental fraternity. Patient's father is stated to be not very bright and to be peculiar.

insertion of recti; muscles which are mottled grey (? Zenker's necrosis). *Omentum* scant in fat. *Lower border of liver* 10.0 cm., *transverse colon* 15.0 cm., below ensiform. *Spleen* blue in color and adherent. *Mesenteric lymph nodes* enlarged and reddened. Lower end of ileum shows dark red fibrin over last 2.5 cm. *Coecum* appears whitish blue in spots. *Appendix* 8.0 cm. in length, bound down by adhesions. *Diaphragm* arches to fifth interspace on each side.

Thorax.— There are hemorrhages at base of right lung anterior. Slight excess of fluid in pericardial sac. Mesenteric, bronchial and retroperitoneal lymph nodes markedly enlarged.

Heart.— Weight, 195 grams. Measures 10 × 10 cm. Coronaries negative. Epicardial fat abundant.

Measurements: T. V. 12.0 cm. P. V. 5.0 cm. L. V. 0.5 cm.
M. V. 10.0 cm. A. V. 7.0 cm. R. V. 0.6 cm.

Fenestrations marked in pulmonary valves. Endocardium grey.

Lungs.— Right lung weighs 680 grams, left 435 grams. Anterior and upper portions of right lung of normal appearance. Posterior and lateral are dark red, mottled grey areas surrounding bronchi.

Left lung negative in appearance, except section shows multiple hemorrhagic cavities surrounding bronchi. Pin points of pus spurt from some of these areas.

Organs of the Neck.— Not removed.

Adrenals.— Not separable from kidneys.

Kidneys.— Combined weight kidneys and adrenals, 285 grams. Kidney measures 11 × 4 cm., cortex 1.0 cm. to 0.6 cm. Capsule intimately adherent. Cortex evenly grey and soft. Apices of pyramids white, red at base. Pelvis not remarkable. Kidney tissue very friable. Other kidney same.

Liver.— Weight, 1585 grams. Measures 21 × 18 × 7 cm. Color deep red, appears somewhat grey. Gall bladder contains somewhat stringy yellow fluid.

Spleen.— Weight, 195 grams. Measures 14 × 8 × 7 cm. Three foetal lobulations. Capsule somewhat thickened. Pulp deep red. No Malpighian bodies visible.

Gastro-Intestinal Tract.— Stomach. Mucous membrane pink. Rugae present. Duodenum: bile stained, otherwise negative. Jejunum: lower part dry. Ileum shows area of faint injection not unlike " rose spots " on upper portion. A little lower a circular ulcer with indurated edges is seen. Lower third markedly congested, shows multiple ovoid ulcers. Peyer's patches not apparently involved. Colon from coecum to rectum beset with oval ulcers measuring 0.3–1 cm. in diameter. These are shallow and red edged. Some show lace work of crisscrossing at base (healing ?).

Head.— Calvarium: frontal 0.2–0.3 cm., occipital 0.3–0.4 cm., temporal 0.2 cm.

Dura mater not adherent; convolutions seen through it. Pia mater injected. Slight suggestion of subpial diffusion of blood.

Palpation shows brain firmer than normal. Right hemisphere appears narrower than left, measures 1.0 cm. more in width at base of frontal lobes.

Base of Brain.— Olfactory bulbs show destruction. Nothing of note in optic nerves. Slight thickening of pia. Greatest width prefrontal, 3.0 cm., frontal, 8.0 cm., mid portion at pons, 14.0 cm., greatest length, 15.5 cm.

Vessels show no anomaly, no sclerosis.

Convolutional pattern not more complex left side but there appears to be more convolutions. Notable windings of angular and supramarginal gyri on left. Brain shows notched occipital poles.

Brain weight, 910 grams. Tigges' formula 8 × 160: 1280 grams. Loss in weight, 370 grams.

General Appearance and Anomalies.

Fairly nourished.
Pigmented skin.
Erosion shins.
Adrenals not separable from kidneys.
Calvarium thin.
Unequal hemispheres.

Acute Lesions.

Zenker's necrosis
Hemorrhagic bronchiectasis.
Fibrinous ileitis.
Dilated heart.

Chronic Lesions.

Periappendicitis.
Perisplenitis.
Mesenteric, bronchial, retroperitoneal lymphnoditis.
Relative stenosis pulmonary and aortic valves.
Cardiac hypertrophy.
Interstitial nephritis.
?Tuberculous ulcers intestine.
Brain weight, 910 grams.

c) Anatomical Description.

The brain of this Mongolian imbecile was small (910 grams) and the cerebellum and pons were noticeably smaller than usual. There was no special asymmetry of the brain which fitted the school of dolichocephalic type. There was a diminution of the coronal circumference of the brain at the plane of the temporal tips. There was a tendency to " rosette " formation in both of the frontal lobes. Both of the precentral gyri were interrupted by transverse fissures. The gyri were a fair width and their summits closely approximated. The corpus callosum was slightly thinner in its posterior third.

There were some minute cysts of softening in various areas (frontal, temporal) the pia mater was slightly hazy and thickened over the entire brain and over the cerebellum. The blood vessels were, in general, not remarkable.

d) Microscopic Examination.

The existence of the cysts of softening might raise the question of syphilis. There was one focus of a few mononuclear cells regarded as of exudative origin about one of the larger blood vessels in the white matter of one area (left postcentral gyrus) but there were no other evidences of exudate except in the frontal region (neighborhood of cysts).

The neuroglia tissues showed a tendency to increase of cells usually slight but occasionally moderately well developed. Satellite cells were occasionally increased and the neuroglia cells along blood vessels were in a few areas increased.

The nerve cells were in general well preserved and in particular the large cells retained a proper quantity of Nissl bodies. In the area where a focus of small round cells was found (left postcentral) there was a focal scarcity of cells in all the layers. Another section (left superior temporal) showed a nerve cell scarcity in the supragranular layers especially at the crown of the gyrus. A like condition was found in the left superior parietal area. On the whole there was a rather extensive tendency, particularly on the right side of the brain (not confined thereto) to supragranular nerve cell scarcity.

e) Anatomical and Histological Summary.

There were some skin lesions in this Mongolian imbecile somewhat suggestive of syphilis. The Wassermann reaction a year before the patient's death at twenty-three years, had been negative. The case was characteristically Mongolian. The nerve cell losses or replacures did not seem characteristic of syphilitic conditions and are far more widespread than the small evidences of lymphocytosis shown. There was no evidence of plasmacytosis.

Synopsis of Findings, Case XX.

a) Clinical.

1. **Physical Development.**— L. Dur., male, born Nov. 21, 1877, admitted Oct. 16, 1900 and died Oct. 8, 1915. In March 1914, patient at 36 years of age weighed 131 lbs., was 5′ 5″ tall, well developed and nourished, weak circulation, cyanotic extremities, exaggerated patellar reflexes, with ulcers of both legs; cranium circumference 22″, cephalic index 72; asymmetrical face, deformed ears; ? saddle nose, poor teeth, flat palate.

2. **Family History.**— Patient one of 5 children, all others stated to be normal. Patient's father was 45 years and mother 36 years at patient's birth: patient fourth child.

3. **Personal and Developmental History.**— Patient's peculiarity first manifested itself at 5 years by his not learning readily; his head seemed smaller than the average for his age; began to talk at about 3 years but always stammered badly. Patient began to walk at 2 years. Patient had measles.

4. **History of School Progress.**— Patient had somewhere learned to read and could talk intelligently; was well mannered.

5. **School Examination.**— Nil.

6. **Practical Knowledge.**— Patient worked at Templeton Colony out of doors, doing ordinary rough farm work, using grub hoe, pick and shovel well.

7. **Economic Efficiency** (see 6).

8. **Social History and Reactions.**— At first well-mannered; of extremely nervous temperament; after being taken home in summer for vacation patient always returned much more disturbed and excited than before going. After a few years at the Templeton Colony, patient began to grow childish, developed bad habits and tendencies, lost interest in his work and began to talk to himself. He was then transferred to Waverley (see below).

9. **Moral Reactions.**— Proper until mental change above noted; thereafter became very impatient, constantly asking about mail and papers.

10. **Psychological Tests.**— 6 years; Binet performed Aug. 4, 1914; this reaction is obviously lower than the level which patient would have attained before the mental change.

Waverley School History.— This case apparently developed a mental disease over and above the original mental defect, apparently having periods of delusions and hallucinations, and at times talking and making noises all night, sleeping very little. In March, 1915, patient after having had a long illness with abscess of the thigh, could not talk intelligently. In August, 1915, patient grew thin and pinched, developed diarrhoea, taking to bed; got somewhat better, was up and about in October; took to bed once more and died October 8, 1915. Wassermann reaction Aug. 31, 1915, negative.

b) Autopsy.

Body of a slenderly built, fairly nourished white male, 168 cm. in length. *Skin* white and fine in texture, elastic, rosy grey in color except for a *bruise* 8.0 cm. below right iliac crest, 5.0 × 3.0 cm.; this is purple in color. Scar over right buttocks, 8.0 cm. external to sacral ridge, 3 × 2 cm. From the knees downward the skin is brownish in color surrounding lighter areas ? site of old ulcers. *Abrasions* exist over right knee and left shin in the midst of this brown, shiny area of pigmentation. Marked edema dorsum of right foot; slight edema dorsum of left foot. Skin is scaling over left index finger and slightly over right.

Legs unequal in size; mid calf region, right, measures 28.0 cm., of left 25.5 cm.

Hair.— Slight growth in axillae; marked growth around nipples, moderate amount over thighs and pubis.

External genitalia well developed. No lymph nodes palpable.

Ears.— Right measures 6 × 4 cm.; left 6 × 2.5 cm. Right ear is markedly thickened especially in its upper half and is much broader than the left. Ear lobes not adherent.

The palpebral fissures not large enough to accommodate eyeballs. Pupils — right 0.8 cm., left 0.8 cm.

No teeth present.

Somewhat yellowish flush to face and neck.

Body lies in left lateral decubitus. No bed sores.

Rigor mortis present.

Ventral Section.— Fat over abdomen scant as it is over chest. Muscles deep red in color except intercostals which are paler. The costal angle is broad. Free fluid in peritoneal cavity. *Lower border of liver* 3.0 cm., *transverse colon* 15.0 cm. below ensiform. *Mesentery* contains considerable fat and the lymph nodes are everywhere prominent and red in color. *Omentum* scant in fat. *Spleen* free. *Appendix* 1.3 cm. in length, injected at tip. *Diaphragm* arches to 4th rib on right, 5th on left.

Thorax.— Right pleuric cavity free; left filled to overflowing with reddish fluid. Pericardium uncovered, shows some frothy material in its upper layers. The heart floats in the excess of pale pericardial fluid, estimated at 150 cc. The left lung is adherent lightly to the chest wall.

Heart.— Weight, 255 grams. Measures 10 × 10 cm. Epicardial fat fairly normal. Coronary vessels negative. Tricuspid valve thickened somewhat at edges.

Measurements: T. V. 13.0 cm. P. V. 6.0 cm. L. V. 1.4 cm.
M. V. 10.0 cm. A. V. 7.0 cm. R. V. 0.5 cm.

There is an anomaly in one leaf of the pulmonary valve. The free edges measures 1.3 cm. in length against 2.3 cm. of the other cusps. The free edges of the mitral valve and of the aortic are thickened. The free edges of the aortic valve show some redundancy. Endocardium grey. Myocardium firm. Nothing of note on section.

Lungs.— Weight, left 1360 grams. Right lung is solid to the touch except for a small portion of the anterior edge of the upper lobe. The pleura is covered at intervals with yellowish fibrin. Color of the lung is reddish-yellow. On section yellow semi-purulent material follows the knife and the lung substance is granular and mottled yellow and red. A section sinks abruptly in water. Right lung contains three lobes. There is congestion of the postero-lateral section. Frothy fluid follows the knife. Slight granular change over pleura and congestion of the lung substance.

Organs of the Neck.— Not removed.

Abdomen.— Spleen. Weight, 145 grams. Measures 11 × 7 × 1–2 cm. There are three foetal lobulations on the inferior border. Capsule somewhat thickened but is of a normal slate color. Section shows pulp firm and dark red. Trabeculae not increased. Malpighian bodies not notable.

Adrenals.— Plump and firm. Section shows one to have a greyish center.

Kidneys.— Combined weight, 395 grams. One measures 11.5 × 6 × 3 cm. Capsule slightly thickened; strips with some difficulty tearing portion of cortex. Cortex measures 0.7 cm., is pinkish-red. At one point a small grey body is embedded in the base of a pyramid. This is pinhead in size. Pyramids six in number, injected at bases. Other kidney measures 12 × 7 × 4 cm. and answers same description except that there are 5 pyramids.

Liver.— Weight, 1585 grams. Measures 28 × 20 × 8 cm. Color red dotted with yellow. Capsule somewhat thickened. Section shows lobules well outlined. No apparent increase of connective tissue although the knife is somewhat resisted. Gall bladder dilated; contains clear brownish fluid.

Pancreas.— Negative.

Gastro-Intestinal Tract.— Stomach somewhat dilated; shows no rugae. Mucous membrane grey, drips mucus. No change in upper tract. Six centimeters from ileo-coecal valve is a firm area which shows internally as a vast ulcer. This is irregular and measures 4 × 4 cm. in its massive portion and extends in a serpiginous manner to a maximum of 7.0 cm. Edges are indurated and sloughing, base

extends nearly to serosa. Surrounding this area the mucous membrane is dotted by small ulcers that are somewhat red edged and somewhat constricted at the point of ulceration. The remainder of the tract is free.

Genito-Urinary Tract.— Prostate and bladder not opened. Testicle not examined.

Retroperitoneal Tissues.— Aorta elastic. Sympathetic and peripheral nerves negative. Some lymph nodes along the line of aorta but these are not injected and appear pinkish in color.

Head.— Hair clipped close. Scalp markedly adherent to calvarium. Calvarium measures frontal 0.6 cm., temporal 0.4 cm., occipital 0.9 cm. Middle meningeal artery grooving shallow.

Dura mater not adherent but is thickened evenly. Longitudinal sinus contains yellowish grey adherent clots.

Pia mater somewhat injected and somewhat thickened in sulci.

The prefrontal lobules are indicated by triangular depressions. There is fair complexity of convolutional pattern which is slightly less marked in right of brain. The right parietal is much more simple than the left. The gyri in the frontal region appear small, especially on the left.

There is resistance to the examining finger over the superior surface of the brain and over the inferior surface.

Base of brain.— The first and second nerves are negative; 3rd nerves are involved in a thickening of the pia mater which surrounds them. Vertebral arteries white as is basilar and midcerebrals. Pons and cerebellum firm as are olivary bodies.

Base of Skull.— The posterior clinoid processes measure 2.0 cm. in width; middle clinoid processes 0.3–0.5 cm. The pituitary appears to be walled in and the dura mater which covers it and the stalk of the pituitary is markedly thickened.

Middle ears and Gasserian ganglions negative.

Brain weight, 1390 grams. Tigges' formula 8 × 168: 1344 grams. Gain of 46 grams.

Cord not remarkable on section, appears firm.

General Appearance and Anomalies.

Fairly nourished.
Abrasions, bruises, scars and pigmentation extremities.
Edema feet.
Scaling skin over fingers.
Left lateral decubitus.
Broad costal angle.
Unequal legs.
Unequal ears.
Small palpebral fissures.
Anomaly aortic valve.
Absence prefrontal poles.
Microgyria.
Unequal parietals.

Acute Lesions.

Lobar pneumonia.
Parenchymatous nephritis.
Ulcer intestine ? dysenteric.

Chronic Lesions.

Hydrothorax.
Hydropericardium.
Chronic adhesive pleuritis.
Chronic fibrous endocarditis (valvular).
Hypertrophy heart.
Perihepatitis.
Dura thick.
Pia thick.
General cerebral gliosis.
Thickening vertebral arteries.
Thick pituitary stalk.
Brain weight 1390 grams.

c) Special Anatomical Description of Brain.

The brain was of good size (1390 grams) and of a dolichocephalic type. The convolutions are of fair width, slightly flattened everywhere. A number of anomalies are in evidence; left precentral gyrus interrupted by the first frontal gyrus; right post central interrupted at superior knee; tendency to rosette formation, left intraparietal sulcus; operculum on both sides cut by central fissure; absence of middle commissure. The corpus callosum was thin in both its anterior and posterior third. The basal vessels were small and rather noticeably thickened. The pia mater was slightly thickened and hazy.

d) Microscopic Examination.

Practically all the sections show identical changes though varying slightly in degree. There was a slight moderate increase of neuroglia fibres in the subpial zones, chiefly at the bottoms of the sulci, with focal increases of cells in places. The large Betz cells contained normal appearing Nissl bodies and small amounts of pigment. Satellite cells are numerous, appearing in all cell layers. There was a rather marked increase of neuroglia cells of all forms, both cells producing fibrils and cells with well marked protoplasmic processes. These neuroglia cells were apt to show an increase in groups especially about capillaries. Sometimes there was a small pin-point group of radiating neuroglia cells suggesting a small focus of special degeneration or infection. In the vessel spaces of the medulla and the cerebellum there was even evidence of a slight infiltration with mononuclear cells but in the cortex itself there have not yet been found evidences of chronic inflammation.

e) Anatomical and Histological Summary.

The question again arises for this imbecile, whether he is not syphilitic. It will be remembered that he developed a mental disease with delusions, hallucinations and insomnia over and above his original mental defect. The Wassermann reaction five weeks before death was negative.

The following are brief characterizations of the cases in the present Waverley Research Series (XI–XX), which may be helpful for quick reference and are drawn up like those in the first series (I–X), pages 105–108 of Researches, 1918.

Case XI. This is the first classical "big-head" hydrocephalic of the Waverley Series (Case XII was the second). The value of the case *re* possible syphilitic origin of the "big-head" cases is injured by the tuberculosis which affected the brain before death. Tuberculosis of membranes and substance is associated with exudation, hard or impossible to tell from that of syphilis of the nervous system. The Binet age of Case XI was 1.2 (actual age at death not quite 6 years). The clinical history indicates that little or no further progress was to be expected. The superimposed acute lesions interfere with our judgment whether the nerve cells are hypoplastic (in the sense of a primary arrest); but there is considerable evidence of nerve cell scarcity.

Case XII, the second "big-head" hydrocephalic of the Waverley Research Series immediately followed the first (Case XI). We do not know the actual weight of Case XII's

brain (technical attempts to fix brain in formalin in a certain manner forbade taking its weight); but the weight minus contained fluid was undoubtedly over 1000 grams and probably over 1100 grams. The Binet age of this twenty-year old hydrocephalic was 3.4, a considerable advance of the 1.2 scored by the preceding case (XI). *Re* the possible relation of "big-head" hydrocephalus to neurosyphilis, we find some suggestive foci of chronic inflammation (plasmocytosis), which can be explained by no other hypothesis so easily as by that of syphilis (the cause of death was acute pyelonephritis, and there seems no way of connecting the chronic inflammatory brain foci either with this pyelonephritis or with other existent lesions). The aqueduct of Sylvius was definitely bridged over by neuroglia tissue.

Case XIII. This is the first case of Mongolism in the Waverley Series (Case XIX is another, and three more have since come to autopsy, for description as cases XXI, XXVIII, and XXIX in a third monograph to follow this). The general suspicion concerning Mongolism is that endocrinopathy plays some part therein. Some authors incriminate neurosyphilis; but the numerous microscopic sections thus far examined in Case XIII show no sign of chronic inflammation whatever. *Re* endocrine changes, there was, besides a general *status lymphaticus* or lymphatism (bronchial, mesenteric, retroperitoneal), a persistent thymus, with indications of hypothyroidism, hypoadrenalism and hypopituitarism. But of course the persistence of the thymus in a girl of 18 should not be overstressed. The nerve cells appear thinned-out in various loci. Gliosis was but moderate.

Case XIV. This idiot of 32 (Binet age, 1.3) is in some respects more typical of what we might term "ordinary" low-grade custodial school cases than any other case since Case VI of the first series (but even Case VI had but one vocal cord and showed other stigmata, which served to raise the syphilitic hypothesis). The syphilitic hypothesis can be raised for Case XIV (foci of mononucleosis, even plasmocytosis). The translocation of nerve cells into the white matter is a finding, however, that is either non-syphilitic in origin or is due to some effect excited by syphilis in a peculiar way and probably at an early stage of development. There were no striking lesions or disproportionate appearances in the endocrine system. How important the datum, if we could be confident that no mental change began until the sixth year after a scarlet fever!

Case XV. This case, like XIV, raises again the hypothesis of syphilis (some plasma cells in the meninges and a few foci of mononucleosis); but abscess of liver, otitis media and mastoiditis may have contributed the exudative elements to the brain. On the whole Case XV belongs to the group of unresolved cases (after syphilis, direct brain injury or lesion, and endocrine changes have been thrown out of consideration as insufficiently supported hypotheses). There is, of course, no lack of histopathology of the cerebral cortex

to account for the imbecility (Binet, 2.4 years); there is a well marked poverty of nerve cells, often more marked in the outer layers (supragranular). But the question remains, What was the cause of this cell-scarcity? Is it a hypoplasia with early death of cells having low vitality? Or is it an instance of genuine agenesia in the sense that numerous nerve cells failed to get laid down altogether? Perhaps the latter, since the heterotopia of nerve cells (translocation into white matter) found in Case XIV is not much, if at all, in evidence in Case XV. If we interpret that heterotopia of Case XIV as due to lack of "drive," of *élan vital*, sufficient to carry them out to their proper places, we have some basis for suspecting for Case XIV a degree of aplasia or hypoplasia, rather than an agenesia. Apparently neither XIV nor XV is suspiciously endocrine in general appearance.

Case XVI. This striking case of macrogyria (the "loaf-of-bread" brain) presents problems of its own. The greatest problem no doubt is the cause of the failure of sulcation to develop over the whole top and fore parts of the brain, while at the same time no proper layering was going on inside the brain substance. Now this poor furrowing outside and poor layering inside go hand in hand: as one passes backward and beneath zones of more normal furrowing, one comes upon much better layering, until in the occipital poles there is, if not a normal, then a somewhat familiar looking lamination. Another pretty problem here is the relation of a fairly well developed corpus callosum to an otherwise poorly developed brain. In general, with this brain, we are evidently dealing with some mortific agent or some development-arresting agent, operating in the embryonic life and paying heed not so much to architectural details as to certain major trends on the part of the brain. Which is primary, the flaw in the furrowing process or some hypoplasia of lamination?

Case XVII. This case is the first to classify amongst higher imbeciles in the second Waverley Research Series (Cases XI to XX). The Binet age of Case XVII was seven. There were two cases in the first series having this age; but one of them (Case III) was the case of "Little Zip" whose brain weighed but 610 grams so that only Case IX of the previous series with Binet age seven is directly comparable with Case XVII. Cases IX and XVII with Binet age seven may also be compared with Case XX, Binet age six. The gross appearance of the brain of Case IX was characterized by exceedingly poor moulding, and certain areas of the brain histologically showed stratigraphical alterations of architecture without complications of acquired degrees. In particular the case of the able-bodied imbecile IX, showed heterotopia of nerve cells recalling those described in the present monograph for Case XIV but Case XVII fails to show translocated nerve cells in the cerebrum (slight heterotopia of Purkinje cells in the cerebellum). Accordingly the brain of Case XVII is unlike that of Case IX and that of Case XIV in the important respect of

heterotopia: that is, we argue that there is less evidence for aplasia or hypoplasia (as indirectly indicated by heterotopia of ganglion cells) than in Cases IX and XIV and that Case XVII with its Binet age of seven more resembles Case XV with its Binet age of 2.4 than either of the other cases mentioned. There are no endocrinopathic suggestions about Case XVII. No sign of exudate was found.

Case XVIII. This altogether remarkable case of multiple small cysts with mononuclear cell (including plasma cell) infiltration turned out to be beyond much question syphilitic (histological and clinical evidence). There was a considerable internal hydrocephalus presumably *ex vacuo*, that is, due either to the destruction or the faulty laying down of white matter. Despite the comparatively complex furrowing of the brain, the corpus callosum was very ill-developed.

Case XIX, like Case XIII of this series, was a victim of Mongolism but attained a higher mental age (5.2 as against 3.1). It was noted under Case XIII that there were no lymphocytes or plasma cells found in the areas so far examined, and this was adduced in partial evidence that Mongolism was probably not a matter of neurosyphilis. Case XIX does, however, show a few instances of perivascular infiltration about vessels in two or three areas of cerebrum and cerebellum. No definite plasma cells were made out. There is some question of tuberculosis in the shape of ulcers of the gastro-intestinal tract (histologically not proved), and there is some suggestion of a syphilitic skin lesion of the legs. The Wassermann reaction has been negative. The patient died of typhoid fever and it is probable that the intestinal ulcers were typhoidal. It is curious that the brain of this Mongolian with a Binet age of 5.2 should weigh 910 grams as against the brain weight of 1160 grams in a Mongolian with a Binet age of 3.1. To be sure the Mongolian with the lower mental age (3.1) had a lower actual age (18) than the Mongolian with the mental age 5.2 (actual age 23). It may be remarked that the other organs of the body in Case XIX did not show especial diminution of weight.

Case XX. This case was remarkable from its developing over and above the original mental defect also a well marked psychosis (delusions and hallucinations). The patient had always been nervous. There was evidence in the histology of the cortex of somewhat focal degenerative processes (e.g. pin point groups of radiating neuroglia cells and sometimes mononuclear cell infiltration). The question of neurosyphilis may be raised for Case XX with more assurance than for several other cases with signs of exudative change.

V.

CORRELATIONS BETWEEN MENTAL CAPACITY AND BRAIN COMPLEXITY IN TWENTY CASES OF FEEBLE-MINDEDNESS.

(WAVERLEY RESEARCH SERIES, CASES I–XX.)

With General Conclusions Concerning the Genesis of Certain Cases.

E. E. Southard, M.D. and O. J. Raeder, M.D.

V.

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With General Conclusions Concerning the Genesis of Certain Cases.

E. E. Southard, M.D. and O. J. Raeder, M.D.

The plan of the present article is (a) to make a provisional epicritical review of the problems presented by ten cases (XI–XX) of the Waverley Research Series of cases of feeble-mindedness presented in the previous article of this series. Brief characterizations of these ten cases were given at the end of the previous article; but I here mean to bring more general conclusions resembling those of Article III of these researches, namely the article entitled "Neuropathological Correlations with Clinical and Psychometric Findings in Feeble-mindedness."

I intend (b) to make mutual comparisons not merely between the cases (XI–XX) of the present publication but also of the entire twenty so far reported (Waverley Research Series I–XX). The conclusions must in their nature be tentative, and the editors of the Waverley Researches have all along maintained that no very fundamental conclusions could be hoped for until at least fifty cases have been examined. If the pathologist working in another field than neuropathology is pleased to wonder at the slow pace of such researches, let him consider the number of factors involved and remember that the lamented Hammarberg in his masterly monograph was able to deal with but nine cases and that most of Hammarberg's work in 1895 consisted in determinations of normal features of the brain by way of background for his studies in feeble-mindedness. A like fragmentary view of the whole topic is presented in the great work of Bourneville, in that of Mierzejewski and in the orientation work done here in America by Wilmarth. It is a question whether this series can be completed in its present form in the next few years although the anatomical, photographic and histological work is now advanced through the third and into the fourth series of ten cases.

It is the province of these epicritical articles, interpolated in the series of articles em-

bodying details, to develop in current fashion such ideas as the cases suggest and to strip the husks off the larger problems that future research may undertake. Perhaps the most striking result afforded by the work to date is illustrated in the last plate (Plate XXXII of this publication), a plate showing the twenty brains in two orders highly suggestive of fairly close correlation between mental capacity and brain complexity. It is on this account that the title of the present article has been made to stress the matter of correlation between brain and mind.

Before proceeding to the epicritical review, I may rehearse the general situation presented in the first publication of the Waverley Researches in 1918.

1. That the world ought to have available for conclusions far more properly reported cases of feeble-mindedness with autopsies than are at present at hand, goes without saying. As before remarked, the literature probably contains less than 100 comparable cases (Tredgold's book is founded upon about a dozen cases; many of Bourneville's cases are curiosa). The present series now approaches fifty in the course of study.

2. The practice of systematic external photography and photography of the sectioned brain has been continued. But for the present series photographs reproduced in various degrees of magnification have been used to bring out different points. Attention may be called to the presentation of twenty brains in two orders (psychometric and encephalometric) reduced to very small size (of course all these brains are available in photographs of a much larger size). These photographs made by an expert photographer, Mr. Herbert W. Taylor, are available in enlargements, about twice the size of the original brain for class demonstrations and are at the Massachusetts School for the Feeble-minded and at the Harvard Medical School.

3. The practice of making total brain sections of these brains has been continued; but most of the conclusions concerning the histology of these cases have been drawn from specially cut and stained smaller sections.

4. The "Mierzejewski effect" was mentioned at the end of Article I in the previous publication of 1918, that is, the problem afforded in certain cases of disharmonious development of grey and white matter (grey in excess) in which the commissural system is thought to be deficient. Some attention has been paid to this defect in the present series and casual notes upon it may be found in the description of the photographs printed just before the plates in the present publication.

5. The idea attributed to Dejerine that intellectual capacity may depend more upon cell interconnections than upon cell numbers is an idea which it has not been found possible to pursue though the situation depicted in the last plate (Plate XXXII) shows certain disparities of position in the brains arranged by mental capacity as compared with the

brains arranged by brain complexity. Thus, if "Little Zip's" brain (Case III of the total series) and the able-bodied imbecile's brain (Case IX of the total series) weighed about one pound and about three pounds respectively and if the mental ages of these two patients were approximately equal, then a careful histological comparison of these two brains would yield interesting results upon the question of the Dejerine effect. But to accomplish this correlation would require resources of technique and workers beyond the powers of any institution yet established in the world.

6. The Hammarberg query as to the probable date of origin of various maldevelopments and arrested developments is a query whose answer would have the most profound bearings on education. Perhaps the case we often term the loaf-of-bread case (Case XVI) would be significant here if we could by a combination of arguments from pathology and embryology decide exactly when in the embryonic life this lesion began. If there are two rows of Betz cells in this most remarkably undifferentiated brain, were there two periods of activity in the development of these cells such that one group of cells got more "drive" into the tissues than did the other and what relation does the comparatively well-developed corpus callosum bear to the rest of the brain development?

7. The question of an exact definition in cerebral terms of "plastic impotence" (agenesia) and "plastic arrest" (aplasia) gets some assistance from the present series. Cases with approximately equal degrees of nerve cell scarcity as quantitatively estimated — no one seems able as yet to make exact quantitative comparisons in this direction — may be cases (a) of acquired cell loss, (b) of initial cell lack, (c) of combinations of acquired cell loss and initial cell lack. Some little help is afforded by the degrees of gliosis in these brains, especially if we find a close relation between the gliosis and the nerve cell scarcity in the different areas. And some authors feel that we can attribute some value to the irregularity of disposition of nerve cells on the reasoning that an irregular disposition of nerve cells means some sort of lesion acquired by the brain subsequent to the laying down of the cells. We have felt that a pronounced heterotopia, dislocation or translocation of nerve cells was indirect evidence of aplasia rather than agenesia, arguing that these translocations meant differing amounts of initial "drive" on the part of the cells as laid down. Accordingly, in cases with equal degrees of cell scarcity we have tipped the scale towards aplasia when there was definite evidence of heterotopia.

8. As for the problem of so-called "functional feeble-mindedness" there is little new to report from this series, though possibly the data from Mongolian brains will bear on the question (one of the Mongolian brains with a low brain weight seems to have been credited with a higher mental age than a Mongolian brain of higher brain weight).

Let us now arrange the twenty brains in tabular form in several ways.

First let us present a table (Table VIII) displaying features as in Table II of the publication of 1918 but relating to Cases I–XX rather than I–X.

TABLE VIII.

Number	Age	Mental Age	Brain Weight probably	Focal Destructive Lesion	Hydrocephalus	Exudative Lesion of Rod Cells	Nerve Cell Aplasia	Fibre Loss	Gliosis	Satellitosis	Dislocated Ganglion Cells
I	5	1–, est.	minus	0	moderate	0	marked	marked	slight	0	0
II	20	1–, est.	minus	+	marked	0	marked	marked	marked, patchy	+	0
III	45	7, est.	minus	0	0	0	+	?	+	+	0
IV	62	moron or subnormal	plus	0	+	+	+	+	+	focal	+
V	16	subnormal	normal	0	slight	0	+	0	+	0 (sl) focal	+
VI	26	2, est.	minus	0	0	+ rod cells	slight	?	+	+	0
VII	25	5, Binet	normal	thrombus (hist.)	0	rod cells	slight	?	+	0	0
VIII	36	subnormal	normal	0	0	+	+	0	+	+	+
IX	39	7, Binet	plus	0	0	0	+	0	0	0	+, slight
X	37	2.4, Binet	plus	0	0	?	+	?	+	+	0
XI	5–10/12	1.2	820	+	marked +	+	+	+	+	0	0
XII	20	3.4	2325	0	marked +	plasma +	0	+	+	0	0
XIII	18	3.1	1160	0	0	rod cells	+	0	+	0	0
XIV	32	1.3	1205	0	0	+ plasma	+	0	+	+	+
XV	43	2.4	1070	0	0	+ plasma	0	0	0	0	0
XVI	14	1.0	950	0	0	rod cells	+	0	+	+	0
XVII	31	7.0	1275	0	0	+	+	0	+	+	0
XVIII	9	1.0	1475	+	moderate	+ Meninges: rod cells	0	+ marked	+	0	+
XIX	23	5.2	910	+	0	+	+	0	+	+	0
XX	38	6.0	1390	+	0	+	0	0	+	+	0

In the second series there are no additional cases of pronounced microcephaly. The three cases in the first series (cases I, II, III) bear much the same relation to the combined 20 brains of the 1st and 2nd Series as they did in the 1st Series. They remain at the lower end of the anatomical scale, the third (Case III) alone being displaced in order by Case XVI as of more simple pattern. Case III psychologically still stands out prominently from his anatomical class ranking sixteenth in the combined series of 20 (Plate XXXII). The two smallest brains of the 2nd Series, Cases XVI and XIX, are mildly microcephalic.

In case XVI the "loaves of bread" brain of uniquely simple pattern, the Binet correlation is regular, a simple brain with a simple mind. Case XIX of about the same weight but with much more complex sulcation also rates consistently higher on the Binet scale.

However, weighing but 910 grams and of not a very complex pattern, the psychological rating seems high even at 5.2.

Hydrocephalus was marked in cases XI and XII and moderate in Case XVIII. The evidence of syphilis could not be disentangled from the evidence of tuberculosis in Case XI and therefore the syphilogenic hypothesis of hydrocephalus gains no support here. The other two cases — Cases XII and XVIII — do show much incriminating evidence for syphilis. A prolonged research over more uncomplicated cases is needed to settle this important question. It is certainly of frequent occurrence in hereditary syphilis.

Focal destructive lesions were found in four instances, Cases XI, XVIII, XIX and XX. All these cases also showed exudative changes, in fact the number of cases in the second series is much larger than in the first series, every case (cases XI to XX inclusive) showing exudative products in one form or another. These cases likewise were drawn from a chronic class of institution cases.

Case XVIII yielded the most unusual form of focal destructive lesion in the form of multiple cysts found throughout the white matter of the brain. Convincing histological evidence of syphilis was found. The hydrocephalus which was also present and the cystic degeneration of the white matter seems to suffice for the considerably lower psychometric rating of this case.

Case XIX, one of the Mongolians, showed slight focal degeneration in a few areas, though it was not convincing for syphilis. Case XX with mononucleosis and radiating gliosis in focal distribution, however, bids fair to be syphilitic.

In fourteen cases nerve cell aplasia was evident enough for consideration. In 13 of them gliosis occurred with fair regularity. This might lead us to argue that plastic arrest is a more common factor in feeble-mindedness than has heretofore appeared and thus a more hopeful outlook to treatment, or rather prevention is at hand.

The occurrence of heterotopia in six cases — Cases IV, V, VIII, IX, XIV and XVIII — all brains of a comparatively good appearance grossly (with possible exception of cases IX and XVIII) gives significant warning that the microscopic anatomy must be considered when matching brain and mind.

In the next table (Table IX) the brains have been arranged in the order of their estimated complexity. A comparison with the mental ratings will serve to illustrate the difficulty of correlating brain anatomy with brain physiology.

TABLE IX.

Comparison of Brain Complexity, Brain Weight, and Order of Intelligence in Cases I–XX.
(Arranged in Order of Brain Complexity.)

Number	Age	Brain Complexity	Brain Weight	Intelligence
I	5	a)	400–, est.	1–, est.
II	20	b)	620	1–, est.
XVI	14	c)	950	1, Binet
III	45	d)	610	7, est.
XI	5	e)	820	1.2, Binet
XII	20	f)	2325	3.4
VI	20	g)	1130	2, est.
XVIII	9	h)	1475	1.0
X	37	i)	1450	2.5, Binet
IX	39	j)	1620	7, Binet
XX	38	k)	1390	6, Binet
XV	43	l)	1070	2.4, Binet
VII	25	m)	1270	5, Binet
XIX	23	n)	910	5.2, Binet
XIII	18	o)	1160	3.1, Binet
XIV	32	p)	1205	1.3, Binet
IV	62	q)	1340	Moron or subnormal
XVII	31	r)	1275	7, Binet
V	16	s)	1435	Subnormal
VIII	36	t)	1340	Subnormal

For this purpose the reader is referred to the last plate (Plate XXXII) of this series. Here it is graphically shown that Little Zip (Case III) got by far the most intellectual return per gram of brain weight. The best "camouflaged" brain on the other hand is that of case XIV, a large, fairly complex brain which when viewed through the microscope disclosed an idiot intellect (Binet 1.3). As stated above, consideration of the brain weight and brain pattern is not sufficient in estimating the mental capacity of a certain brain.

Case XIX, the dolichocephalic Mongolian with generalized aplasia, probably showed the best mind per gram weight of brain (910 grams) next to Little Zip. The same comparison made with the other Mongolian brain, Case XIII, next in order of complexity, is even more emphatic because the brain weight of Case XIII is greater by 250 grams (1160 grams) and this case attained to a mental grade of only 3.1 as of 5.2 for the smaller brain of Case XIX. The question of "functional" feeble-mindedness arises here and one might logically ask what rôle an endocrinopathy might play in these cases.

TABLE X.

Comparison of Brain Weight, Corrected Brain Weights, and Order of Intelligence in Cases I–XX.
(Arranged in order of actual brain weight.)

Number, Age, Height (cm.)	Brain Weight Tigges	Brain Weight Age normal (Sex)	Brain Weight Actual	Intelligence
I, 5, 81	648	1282 M	400, est.	1–, est.
III, 45, 126	1008	1348–66, M	610	7, est.
II, 20, subn.	?	1358–96, M	620	1–, est.
XI, 6, 102	816	M	820	1.2
XIX, 23, 160	1280	M	910	5.2
XVI, 14, 128	1024	M	950	1
XV, 43, 152	1216	M	1070	2.4
VI, 26, 158	1264	1358–96, M	1130	2, est.
XIII, 18, 139	1103	F	1160	3.1
XIV, 32, 159	1272	M	1205	1.3
VII, 25, 146	1168	1234–39, F	1270	5
XVII, 31, 160	1280	F	1275	7
IV, 62, 141	1128	1178–1210, F	1340	Moron or Subnormal
VIII, 36, 179	1432	1365–6, M	1340	Subnormal
XX, 38, 168	1344	M	1390	6
V, 16, 168	1344	1358–96, M	1435	Subnormal
X, 37, 144	1152	1365–6, M	1450	2.4
XVIII, 9, 115	920	M	1475	1
IX, 39, 178	1424	1365–6, M	1620	7
XII, 20, 148	1184	F	2325	3.4

Table X presents the 20 cases in the order of brain weight. For comparison the brain weights as estimated by Tigges' formula (eight times the body length in centimeters equals the brain weight in grams) and the normal weights for given age and sex (Vierordt's statistical tables) are placed in parallel columns.

TABLE XI.

Comparison of Order of Intelligence with Complexity of Brain in Cases of I–XX.

Number	Actual Age	Intelligence	Brain Complexity	Remarks
I	5	1–, est.	a)	
II	20	1–, est.	b)	
XVI	14	1	c)	
XVIII	9	1	h)	
XI	6	1.2	e)	
XIV	32	1.3	p)	
VI	26	2, est.	g)	Vocal cord absent
XV	43	2.4	l)	
X	37	2.4	i)	
XIII	18	3.1	o)	
XII	20	3.4	f)	Brain weight 2325!
VII	25	5 (2–3)	m)	
XIX	23	5.2	n)	Insane Imbecile
XX	38	6	k)	
IX	39	7	j)	
III	45	7	d)	"Little Zip"
XVII	31	7	r)	
IV	62	Moron or Subnormal	q)	Almshouse transfer
V	16	Subnormal	s)	Dementia Praecox
VIII	36	Subnormal	t)	Murderer

Table XI lists the cases of the combined series according to the estimated intelligence. A combination of this table and table IX has resulted in the construction of Plate XXXII which presents these relationships in more graphic form.

A comprehensive macroscopic review of the 2nd series, Cases XI to XX, is given in table XII, including the bony and fibrous coverings of the brain together with brief information about the cerebellum and spinal cord.

From a careful consideration of Plate XXXII, some difficulties of our first problem, matching brain complexity with testable mind are brought forth in bold relief. It will be readily seen that the microcephalics in a general way represent the lowest intellects and the larger brains rest on the higher intellectual planes. But more striking is the fact that the more complex brains rate higher with some exceptions than the simpler patterns. In other words gross brain defects correlate readily with idiot and low-grade-imbecile intelligence and very complex looking brains correlate with moron and slightly subnormal minds. Of the combined series of 20 brains, 12 cases, mostly at the ends, correlate between brain complexity and testable mind is readily demonstrated. But certain glaring exceptions are perceived with equal facility.

If now the microscopical anatomy of these exceptional cases be considered, an additional number of cases can be correlated. The marked focal heterotopia of Case XIV at once unmasks this seemingly complex brain and brings it much more closely to its place in the anatomical order indicated by its low Binet. A similar adjustment follows in Case XVIII when the cystic degeneration and hydrocephalus are found in section. The exudative lesions and other evidence of syphilis not visible in the gross are sufficient to make a satisfactory correlation.

The case of Little Zip remains as before, unexplainable. With the light of further research both of a much larger series of cases and a much finer histological examination apparent discrepancies between brain and mind may be partially cleared.

The question of theoretically preventable feeble-mindedness receives some help, apparently, from the Second Series. The question of syphilis comes up strongly in Cases XII, XX and positively in Case XVIII; to a less extent but strongly suspicious in Cases XIV, XV and XIX. This would seem to be too high a percentage of syphilis. In a nosological study of 100 autopsied cases of feeble-mindedness in which these two series were included, O. J. Raeder found 15% with strongly presumptive evidence of syphilis.

Case XVIII was theoretically preventable and possibly Cases XII and XX also.

In Case XIV the infectious etiology (scarlet fever) is again strongly suspected. The symptoms are said to have dated from the time of the fever, beginning with abasia possibly of central toxic origin.

Cases XIII and XIX, the two Mongolians, if this peculiar and well delineated feeble-mindedness be solved by the endocrinologist, would probably be helped at least by organotherapy. Extensive and fundamental research in a large series of autopsied cases of carefully studied Mongolian Idiots would no doubt help greatly to solve this important problem. Metabolism studies with functional observations and attack along the lines of röentgenology to show bone development and histochemistry would seem to be indicated.

The second series is replete with neurological lesions worthy of special attention. The most striking abnormity is Case XVI, the "loaves of bread" brain. The almost complete lack of sulcation on top resembling the picture of a foetal brain, makes for a brain pattern than which no simpler example has come to our knowledge. The irregularity or focality of this macrogyria one might almost say agyria confined to the top and slightly more to the right side is noteworthy. For in the temporal convolutions complication advances rapidly, whereas by the base posteriorly one would hardly recognize the same brain. On section the centimeter thick cortex over the frontal lobe halts the eye. On microscopical examination the absence of lamination and homoplasia of cells is no less striking. Two distant rows of Betz cells were found. There was no suggestion of Vignal's layer in the cerebellum. One sees here a thickly laid cortex rich in cells that has not been spread out. With the development and differentiation of the normal cortex laminations, the formation of gyri and spreading out of the cortex would have followed.

The peculiar reaction to syphilis in case XVIII resulting in cystic degeneration with cell proliferation about small vessels in the white matter has already been noted. The transversity of the Rolandic fissures especially at the upper end in the Mongolians (Cases XIII and XIX) with relative shortening of the frontal convolutions is noteworthy since it has been observed in other cases of the next series. In many instances the formation of generally regarded chronic changes, mononucleosis for example, were found after infection of short duration (weeks). In Case XII the blocking of the aqueduct of Sylvius by neuroglia tissue apparently was a cause of the marked hydrocephalus.

Studies of the commissural system are suggested as one observes such cases as Case XVI mentioned above where in spite of the poorly developed cortex cells the corpus callosum is remarkably well formed.

TABLE XII.

Case Number	Calvarium	Dura Mater	Pia Mater	Vessels	Brain Weight Grams	Gyri	Diffuse Atrophy or Aplasia	Focal Atrophy or Aplasia	Corpus Callosum
XI	Thickest by longitudinal fissure; left frontal eminence prominent	Adherent except at vertex	Focal duropial adhesions; fibrinous exudate at base (tuberculous)	Negative	820	Hydrocephalus	Marked	Right more atrophic	Translucent membrane
XII	Wormian bone; right side larger	Focal adhesions to pia	Focal adhesions	Negative	2325 (Probably app. 1000-fluid	Hydrocephalus	Marked	Aplasia of 2nd rt. frontal and hippocampal	Thin
XIII	Fontanelle thin; other irregularities in thickness	Adherent by longitudinal fissure, esp. left	Olfactory nerves adherent	Basilar small	1160	Asymmetries marked	Absent	Depressions orbital surfaces Minor anomalies	Posterior ⅔ thin
XIV	Dense without diploe	Thickened by longitudinal fissure & along middle meningeals	Focal thickenings, vertical. Focal edema Exudate basal. Adhesions about the 4th ventricle	Posterior cerebrals unequal	1205	Fissuration simple	Cerebellum exposed	Right parietal small	Slightly thin in posterior third
XV	Scalp adherent	Adherent Mid. vertex thick and yellow, pacchionian bodies	Basal thickenings irregular, thick along vessels. Slight focal edema	Negative	1070	General gliosis anomalous fissuration	Absent	Both temporals narrow	Mid. portion slightly thin
XVI	Negative	Negative	Sl. thickening about 3rd nerves	Negative	950	Macrogyria	Deficient fissuration	Absent	Normal looking
XVII	Negative	Slightly thick over vertex and middle	Sl. cloudy over vertex. Edema parietal and central. Sl. acute exudate base	Small somewhat white	1275	Complex	Absent	Absent	Slightly thin posterior ⅔
XVIII	Negative	Adherent throughout	Cloudy esp. left and anteriorly	Left vertebral small	1475	Pattern fairly rich	Atrophy present	Left orbital	Generally thinned out
XIX	Thin	Negative	Slight thickening basal	Negative	910	Minor anomalies	Aplasia present	Absent	Not remarkable
XX	Negative	Thick	Sulcal thickenings & basal thickening	———	1390	Fairly complex minor anomalies	Absent	Depressions prefrontal	Thin posterior third

TABLE XII (*continued*).

Middle Commissure	Consistence	Sclerotic Foci	Other Foci Destructive	Ventricles Hydrocephalus	Cerebellum	Spinal Cord	Remarks
Absent	Left hemisphere firmer than right	Absent	Absent (tuberculous meningo encephalitis)	Chronic internal hydrocephalus	Left side firmer than right	Tuberculous meningitis	
Absent	Normal	Absent	Temporal tips parchment like	Chronic internal hydrocephalus	Small also pons	Negative	Pituitary small; choked discs
———	Not remarkable	Absent	Absent	0 or slight	Negative	Thoracic hemorrhage	Clinoid processes peculiar Pituitary fibrosis
Present	Slight increase esp. frontal	Absent	Absent	0	Negative	Negative	Clinoids peculiar Optic discs unequal
Present	General increase	Hippocampals esp. firm Pons and bulb firm	Absent	0	Negative	Negative	Olfactory tracts thin
Probably absent	Soft	Absent	Absent	0	Negative	Soft	Gasserian ganglia small
Present	General increase superiorly	Absent	Absent	Granulation 3rd slightly 4th	Negative	Negative	Cyst pineal
———	Generally increased	Absent	Numerous cysts	Present probably ex vacuo	Firm	Firm	———
———	Not remarkable	Absent	Absent	Absent or slight	Negative	Negative	Olfactory bulbs thin
———	Increased	Absent	Absent	Absent	Negative	Firm	———

Summary.

The provisional conclusions drawn from the second series and the combined first and second series are much in agreement with the original conclusions drawn from the first Series which were as follows.

First that measurable brain can be correlated with testable mind in the low and high orders with fairly positive results. That is the small simple brains represented the low intellects or idiots and the most complex brain patterns corresponded to the high grade, moronic and subnormal types of feeble-mindedness. Some glaring exceptions (Case III) still defy solution, whereas others (Case XIV) are replaced nearly to their proper anatomical level by microscopic examination.

Secondly, the matter of secondary or preventable amentia is also given much support in the second series, all but one case showing some evidences of exudative lesion, the evidence of syphilis not the least prominent.

The fact that the double series has upheld the original provisional conclusions gives some hope that a much larger series will yield still more conclusive findings.

Note Regarding Plates of Series XI–XX.

In this series, XI–XX, the scheme of presenting six surface views including top, base, right and left side views and two mesial surface views of each case in uniform size, conduces to a more ready comparison.

A second plate pictures the gross brain sections in like manner. In addition enlarged views of some of the surface views and sections have been given to emphasize particular lesions.

Description of Plates.

Views of Case XI.

The extreme hydrocephalus, greater in the left hemisphere (compare XI–b left side with XI–c right side) is at once indicated by the irregularity in the shape of the brain, resembling a partially collapsed balloon. This is also shown in the folds in XI–a, XI–b, and XI–c, and the puckering indentations of the temporal tips in XI–d. On mesial section the dilated ventricles (padded with cotton fibre) XI–e, XI–f, attest to the marked hydrocephaly. Note the thin corpus callosum.

The shallowness of the sulci as indicated by their stenciled appearance is seen in all the surface views. The sulcal markings in the views XI–b and in the next case, XII–a, remind

one of the anthracotic markings on the surface of an old lung. In XI–a a piece of adherent dura gives evidence of the terminal meningitis (tuberculous).

The dilatation of the ventricles and shallow sulci are more conclusively shown in the gross section photographs XI–g to XI–n. In XI–m and XI–n one notes that while the left ventricle is stretched to a greater degree there is a greater amount (thicker wall) of grey and white matter on the left.

The thinned out corpus callosum in this case and the next (Case XII) when considered in conjunction with the relatively lessened amount of white matter might give some support to the Mierzejewski theory of deficient commissural fibres.

Views of Case XII.

Another case of marked hydrocephalus, in many respects similar to Case XI, but probably not quite so extreme. In XII– the irregular dilatation of the two hemispheres is noted, greater in the left posterior and right anterior cornua of the ventricles. This is also brought out in the cross-sections XII–i (lower section) compared with XII–j where the greater dilatation is on the opposite (left) side.

Note again the shallow fissuring both as seen from the surface and in the gross sections.

Note also the remarkable fenestration of the septum pellucidum XII–e and XII–f giving the arachnoid appearance of a lacy curtain.

Views of Case XIII.

A fairly large (1160 grams) round brain of a Mongolian idiot. The left hemisphere is larger than the right (XIII–a, XIII–b and XIII–e). One is struck by the transversity of the upper ends of the Rolandic fissures (XIII–a). This places them farther front and shortens the frontal gyri, especially the first and second frontal considerably. This transverseness or forward placement of the Rolandic fissures with resultant shortening of the frontal convolutions and increase of post Rolandic areas, especially in the superior parietal regions, is evident in other Mongolian brains (Case XIX) of this series (and Cases XXI, XXVII, and XXIX of the 3rd series).

The large brain sections were not remarkable and have been omitted.

There is inequality in the post and precentral gyri of the two sides (XIII–a, XIII–b and XIII–c) and the right pre- and post-central gyri considered as a whole are smaller than the left pre- and post-central taken together.

There is a tendency to macrogyria in the frontal and parietal areas and possibly in the right occipital. In the left occipital region the gyri are small, as are also both first

temporal convolutions (XIII–c and XIII–d), the left one being irregular and moniliform in outline.

The brain pattern in general is relatively simple; the smaller sulci being mostly absent or poorly developed.

Views of Case XIV.

This is a comparatively large brain of unusually complex pattern for such a low mentality (Binet 1.3). There are, however, certain irregularities and inequalities. The posterior two thirds of the brain appear somewhat small for the rather large rounded anterior lobes (XIV–a, XIV–b, and XIV–c). This may account for the protrusion of the cerebellum behind.

The postcentral gyri are unequal, the left in general larger and thicker than the right (XIV–a). The first temporal on left shows a marked irregularity, its fellow being better developed.

The right temporal tip is broader and more rounded coming much nearer the center line (XIV–d). The lobus pyriformis on the left appears larger (XIV–d).

The gross sections (XIV–g to XIV–n) show a fair proportion of white and grey and deep (not abnormal) sulcation. There is no hydrocephalus.

Evidence for the most part in this brain is found in the microscopy, viz., in the marked heterotopia and focal aplasia of ganglion cells.

Views of Case XV.

Photographs XV–a, XV–b, XV–c, XV–d picture a fairly complex looking brain, so much so that the central gyri are outlined with difficulty (XV–a).

The first temporal gyri are irregular (XV–b and XV–c). The left is small and shortly lost. The right is much larger and well developed.

The corpus callosum shows some thinning in the middle third (XV–e and XV–f, and less distinctly in XV–i and XV–j).

The ventricles are slightly enlarged probably not from distention, but lack or aplasia of brain wall.

The most convincing argument for feeble-mindedness in this case lies in the microscopical picture, namely, the marked aplasia in some regions.

Views of Case XVI.

This brain macroscopically one of the most remarkable of the whole series. The extreme anisogyria top (XVI–a) compared with base (XVI–b). The marked macrogyria is

confined to the top (XVI–a) and front (XVI–b and XVI–c) mostly. In the temporal lobes and occipital lobes and on the base gyration comes nearly to normal in appearance. The left hemisphere is shorter. The left gyrus rectus (XVI–d) is unusually large. The corpus callosum is relatively large (XVI–e, XVI–f, XVI–h, XVI–i and XVI–k).

The enormous thickness of the cortex (XVI–h, XVI–i, and XVI–k) is shown corresponding to the macrogyria (XVI–a, XVI–c and XVI–d), and likewise the more normal cortex is seen where the cells microscopically begin to show lamination. There is also a slight enlargement of the ventricles, most likely due to aplasia of the surrounding brain matter. The correlation of marked heterotopia with the undeveloped cortical lamination is noteworthy.

Views of Case XVII.

The brain pattern is complex (XVII–a); there is a striking defect in the first left frontal convolution near the vertex. The temporal lobes are well rounded, especially the tips (XVII–d) though separated. The occipital poles are somewhat small (XVII–b) especially the right (XVII–c). The corpus callosum (XVII–k, XVII–l, XVII–o) is fairly large though somewhat thinner in the posterior third (XVII–j and XVII–k and XVII–l). The gyral tips tend to point rather than round off especially in prefrontal region.

The most convincing evidence for feeble-mindedness is in the microscopic picture, namely, the aplasia and gliosis.

Views of Case XVIII.

A fairly large brain (1475 grams) but a considerable degree of hydrocephalus (XVIII–h, XVIII–i and better XVIII–j, XVIII–k, XVIII–l and XVIII–o). Externally the atrophy of gyri separated by wide sulci is the most prominent feature (XVIII–a, XVIII–d and XVIII–e, XVIII–v). The crura appear shrunken away from the hippocampal gyri (XVIII–i). The marked asymmetry of the temporal tips is also noted here (XVIII–i), the left being smaller and acuminate. There is marked thinning of the corpus callosum, especially in middle and posterior third, (XVIII–h, XVIII–i and XVIII–l, XVIII–s, XVIII–t). This case again as in cases XI and XII, bring up the question of a deficient commissural system, the so-called "Mierzejewski effect."

Remarkable is the cystic degeneration in the white matter (XVIII–m, XVIII–n, XVIII–o, XVIII–p. See also micro-photographs XVIII–u, XVIII–v, XVIII–w).

Further evidence of feeble-mindedness is found in the cell pictures, viz., heterotopia, granular degeneration and exudative products.

Views of Case XIX.

This is a small (910 grams) Mongolian brain, the second of the series (see Case XIII). The brain pattern is relatively simple and there is moderate macrogyria. The forward placing of the Rolandic fissure inclining toward a transverse direction with resultant shortening of the frontal convolutions, is again evident (XIX–a) though not quite so marked as in Case XIII. There is little cross fissuring in the post-central gyri which are smooth and regular. The pre-central gyri are both crossed by deep transverse fissures (XIX–a, XIX–b, XIX-c). The occipital poles are unusually plump and well developed (XIX–b, XIX–c and XIX–e, XIX–f). The temporal tips (XIX–h) are somewhat asymmetrical, notching of the left. The right cuneate lobule (XIX–f) is slightly larger and more complex than the left (XIX–e).

There is probably a slight dilatation of the ventricles (XIX–k, XIX–l, XIX–m and XIX–n).

Views of Case XX.

Large fairly complex brain of an imbecile (XX-a). A considerable number of developmental irregularities, however, are shown. The right hemisphere (XX–a) has a much simpler pattern than the left, especially marked in the parietal and less in the superior frontal regions. The precentral gyri are deeply cross fissured. On the left the first frontal convolution suppresses the upper end of the precentral convolution entirely.

The right occipital lobe is larger than the left (compare XX–b and XX–c). Note also this relation in the cunei (XX–e and XX–f). The corpus callosum is somewhat thinned posteriorly (XX–m).

PLATE XXXII.

Correlating Brain Complexity with Mental Capacity.

In the lower part of the figure, miniature reproduction of the 20 brains of the combined Series I and II, are arranged in anatomical order. In the upper group the same brains are arranged according to Binet intelligence values. The extent to which it has been possible in this short series to match measurable brain with testable mind is shown by the lines connecting the anatomical and psychic levels of each case.

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NOTE — This bibliography is a continuation of the bibliography given in the 1st series, to which the reader is referred for the years 1860 to 1915 inclusive. The bibliography is founded on the card catalogue of the Massachusetts School for Feeble-minded at Waverley and is selected. Unimportant articles have been omitted and an endeavor has been made to include especially studies of a pathological nature and such psychological and clinical works that appear to advance our knowledge of Feeble-mindedness.

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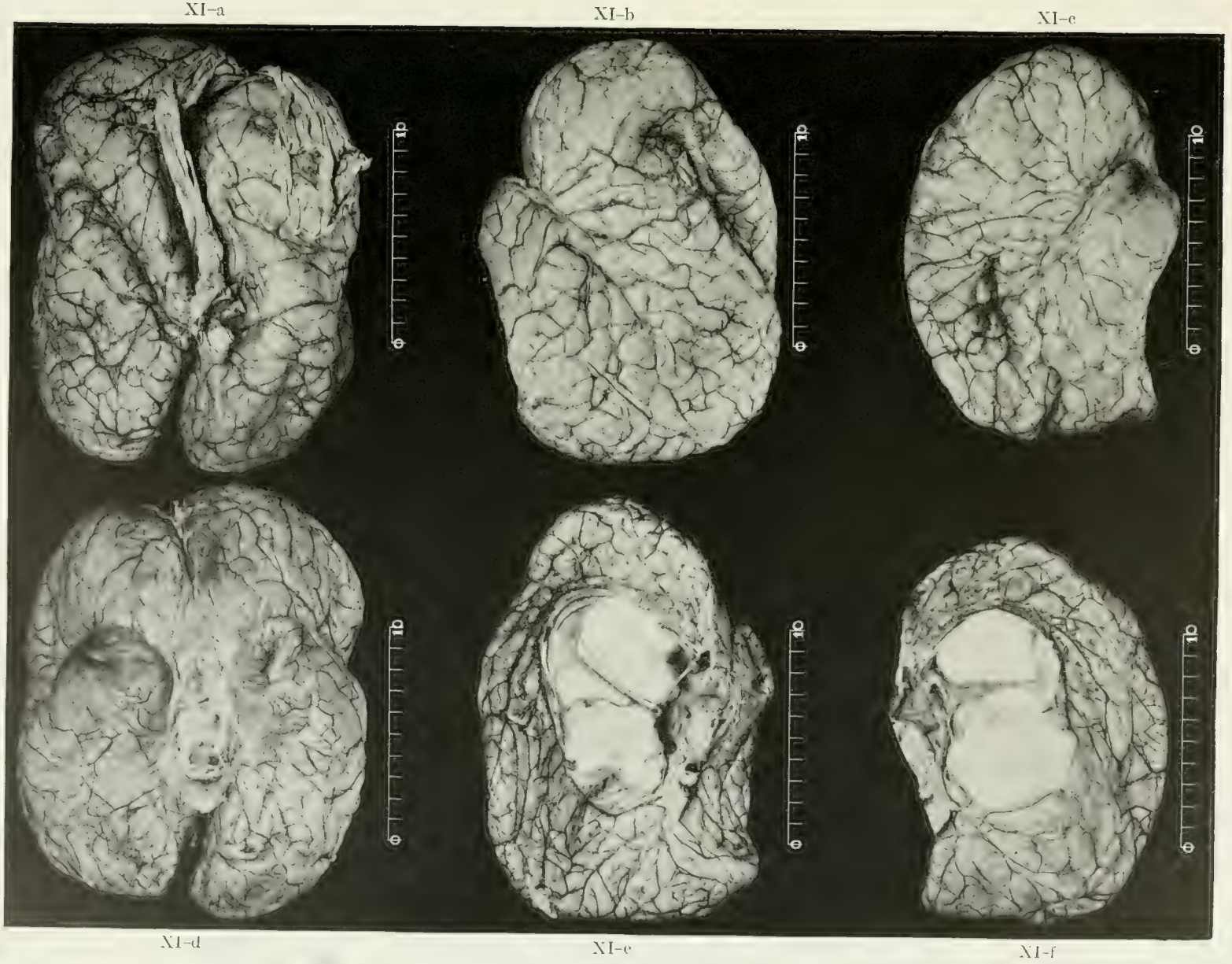
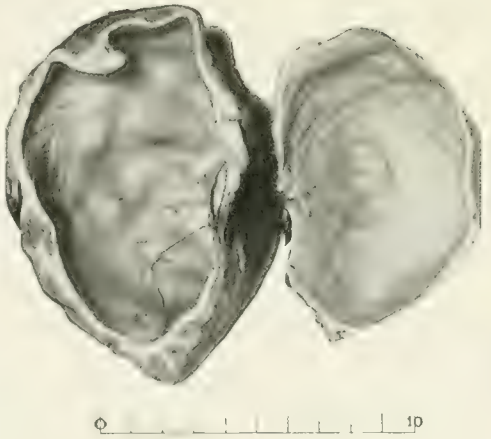


CASE XI – HYDROCEPHALIC IDIOT

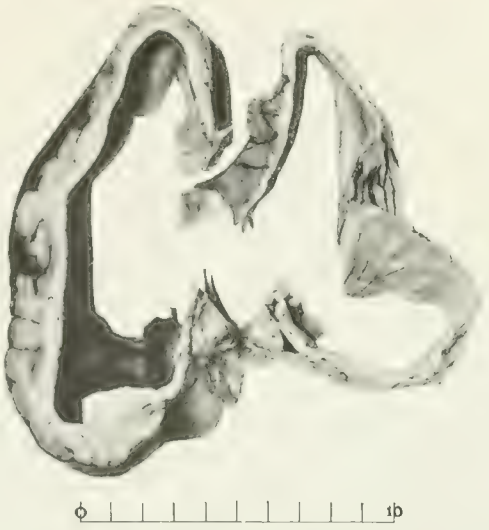
XI–g



XI–h

XI–i

XI–j



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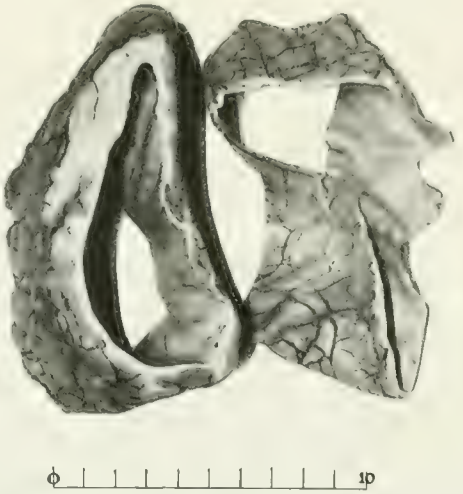
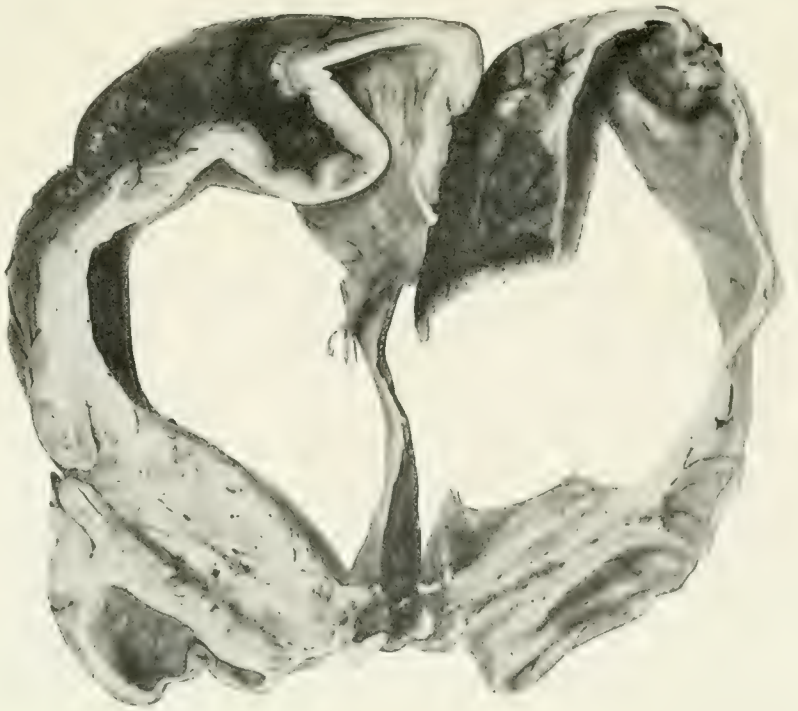


XI–l

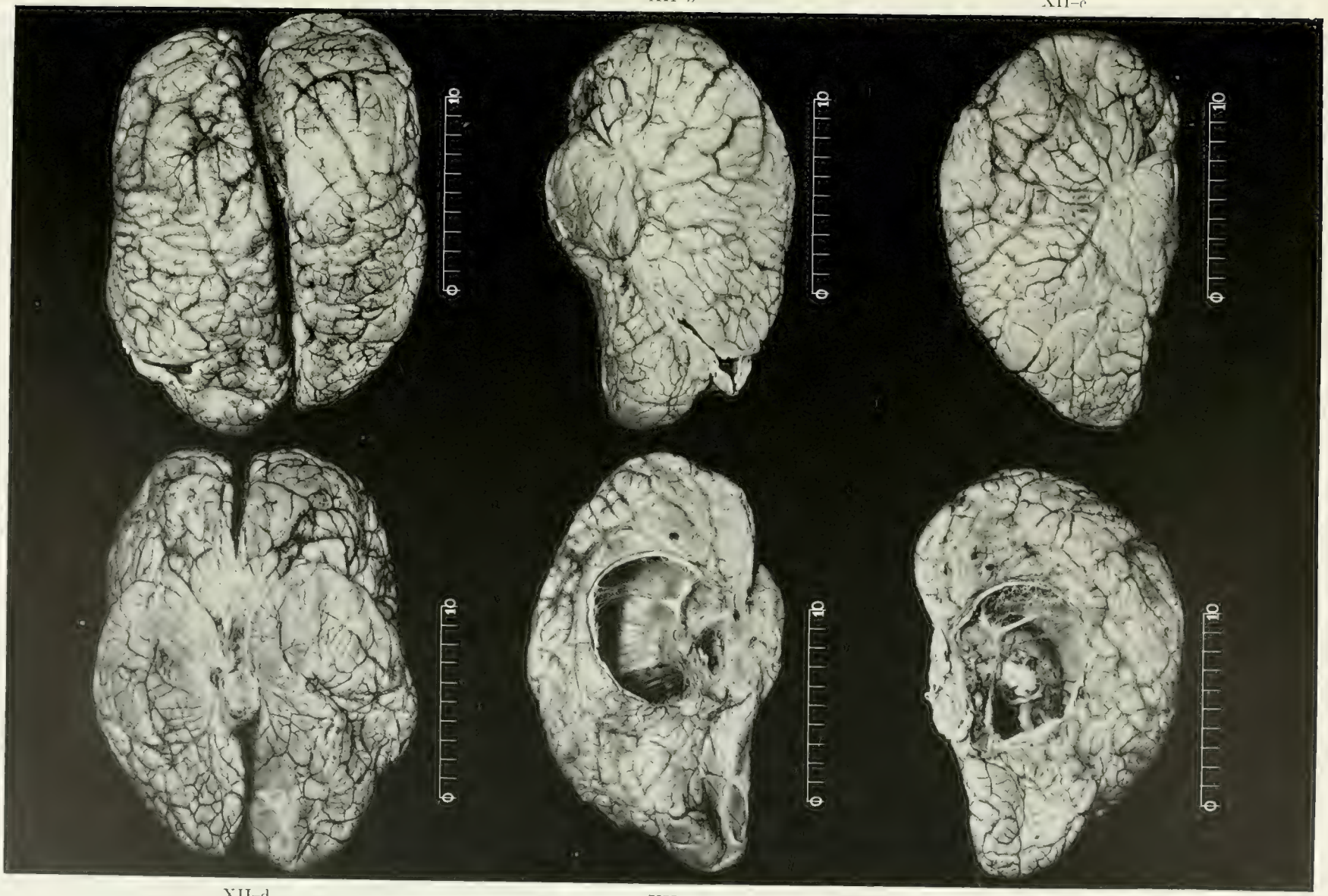
CASE XI.—HYDROCEPHALIC IDIOT



XI m

XI n

CASE XI — HYDROCEPHALIC IDIOT



CASE XII — HYDROCEPHALIC SYPHILITIC

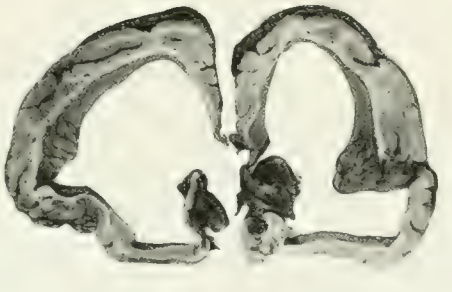
XII–g–h

XII–i

XII–j

XII–k

XII–l

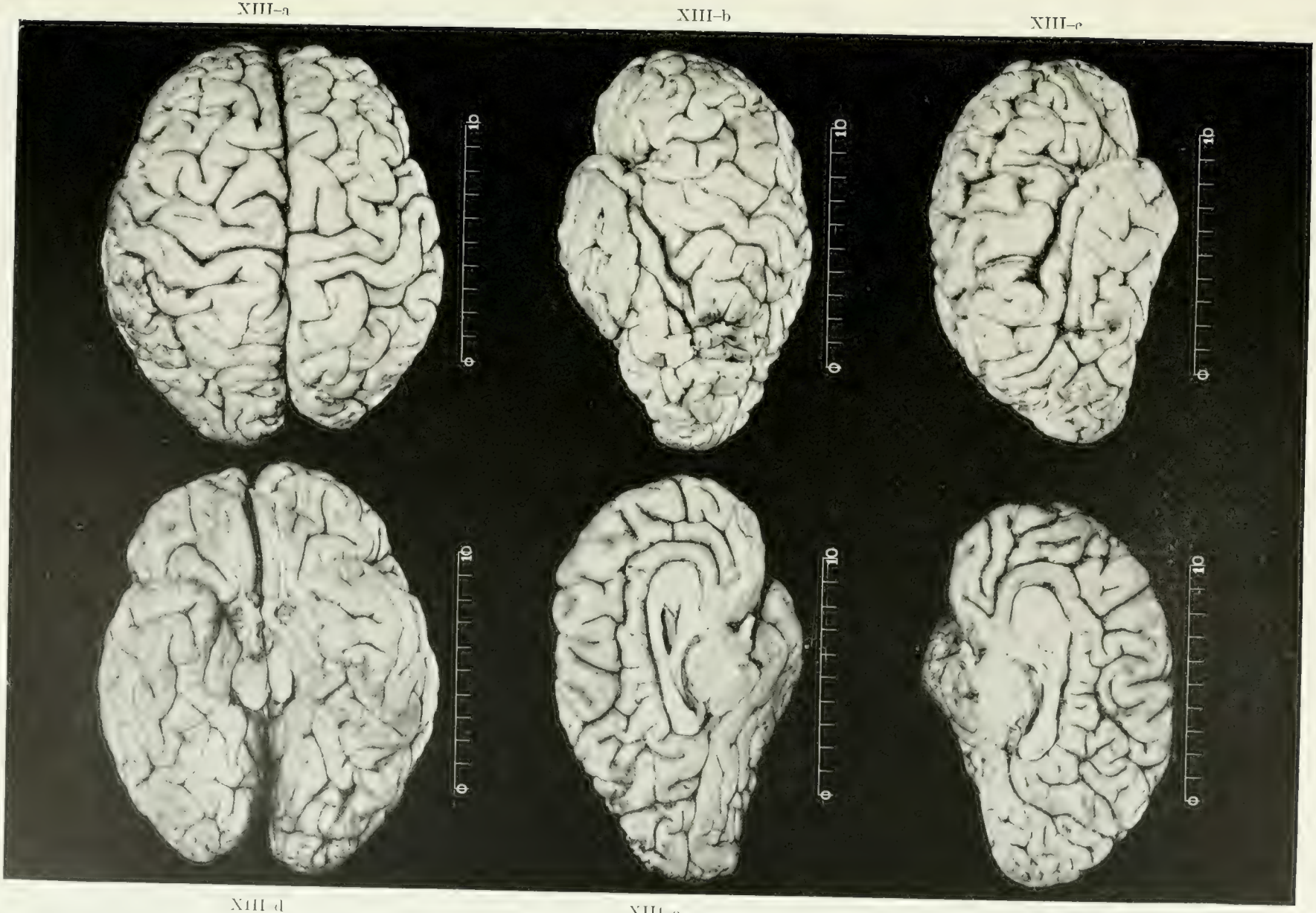


XII–m n

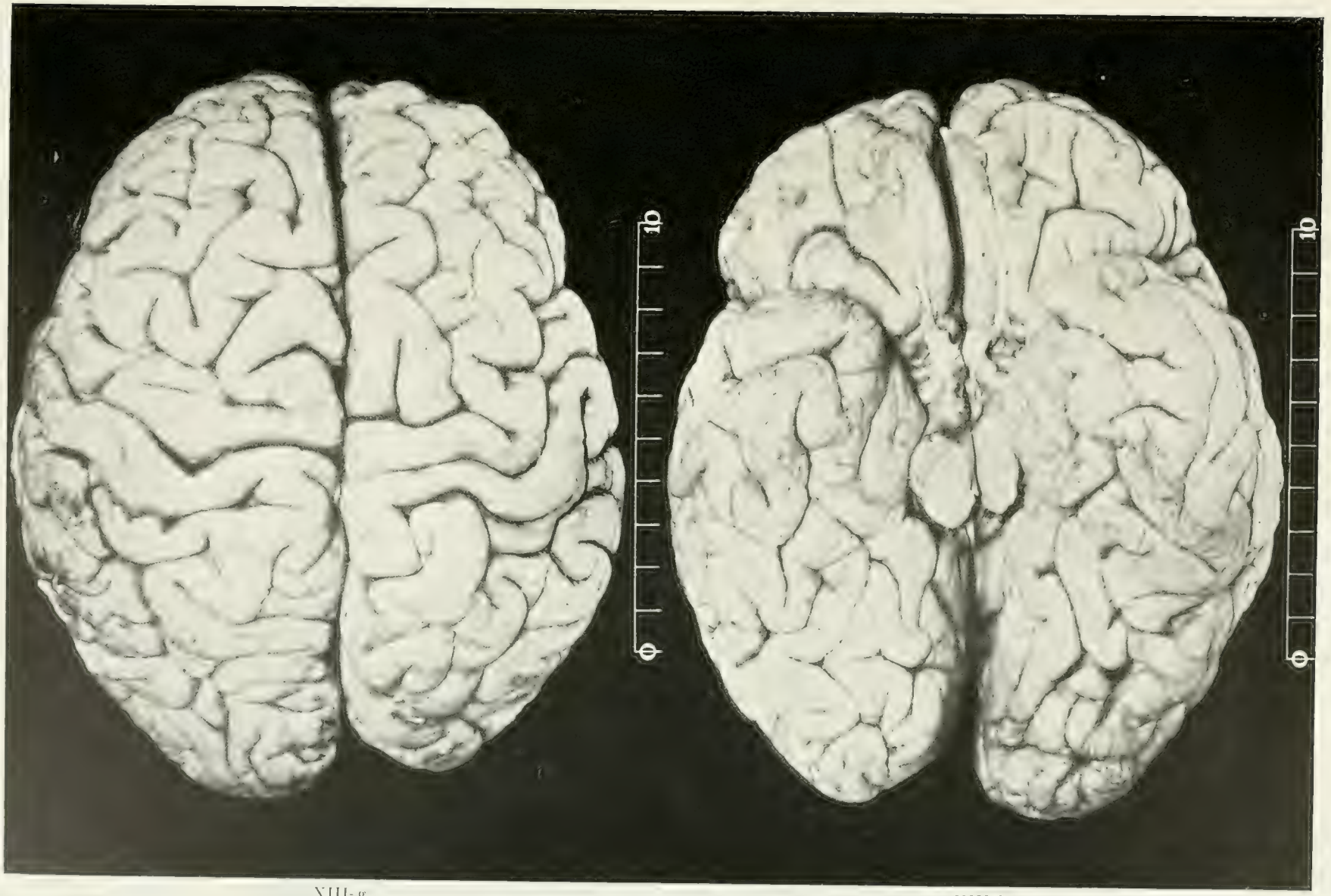
CASE XII — HYDROCEPHALIC SYPHILITIC

XII–o XII p

CASE XII — HYDROCEPHALIC SYPHILITIC

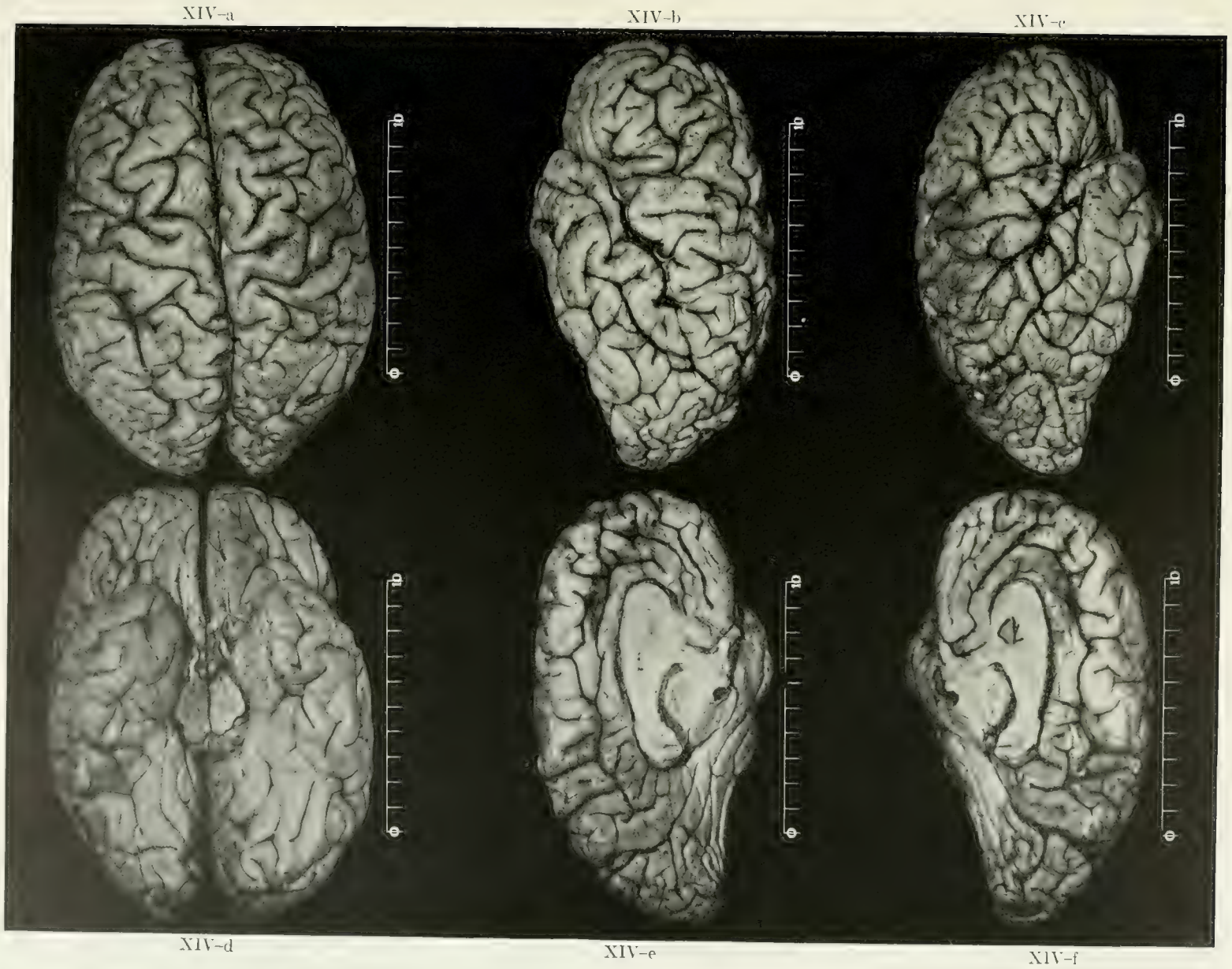


CASE XIII MONGOLIAN IDIOT



XIII-g XIII-h

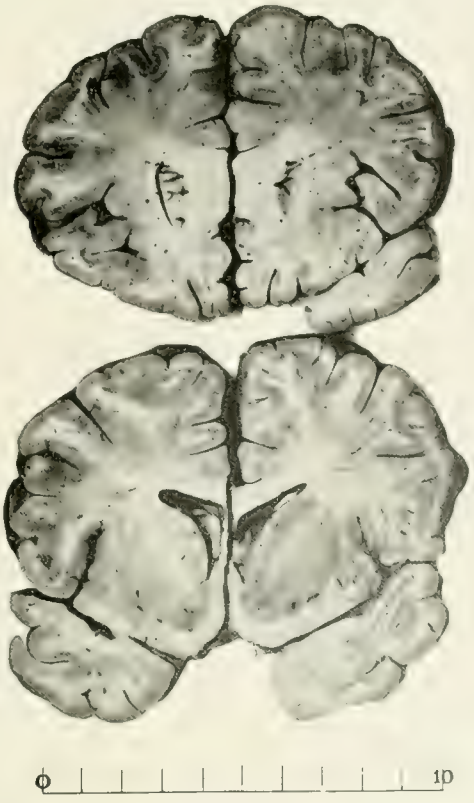
CASE XIII - MONGOLIAN IDIOT

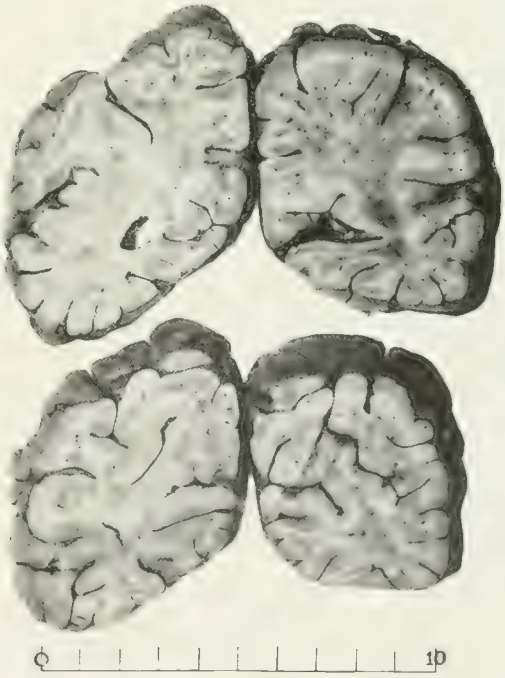


CASE XIV — IDIOT

XIV–g–h

XIV i–j

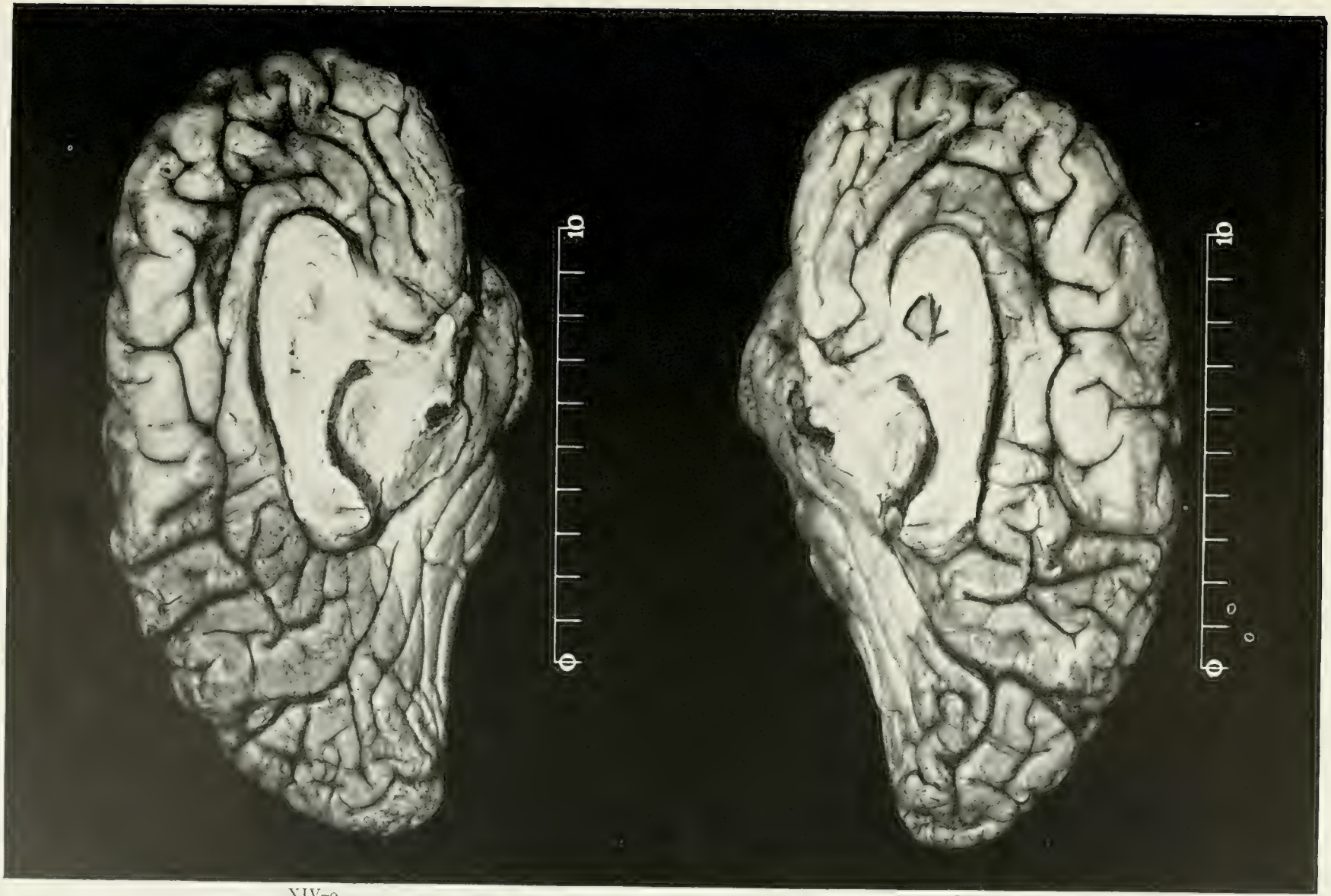




XIV–k–l

XIV–m–n

CASE XIV — IDIOT

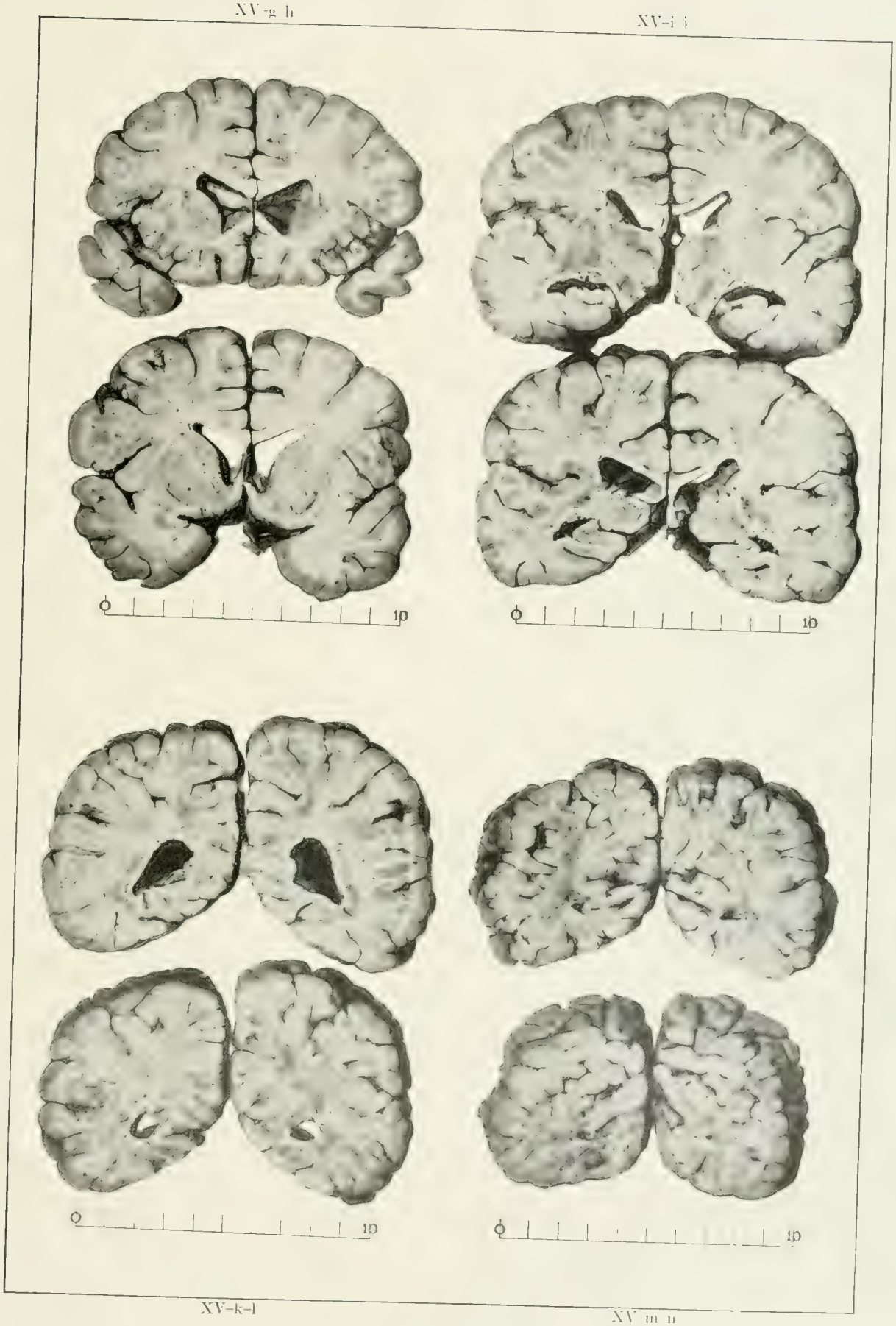


XIV–o

XIV p

CASE XIV — IDIOT

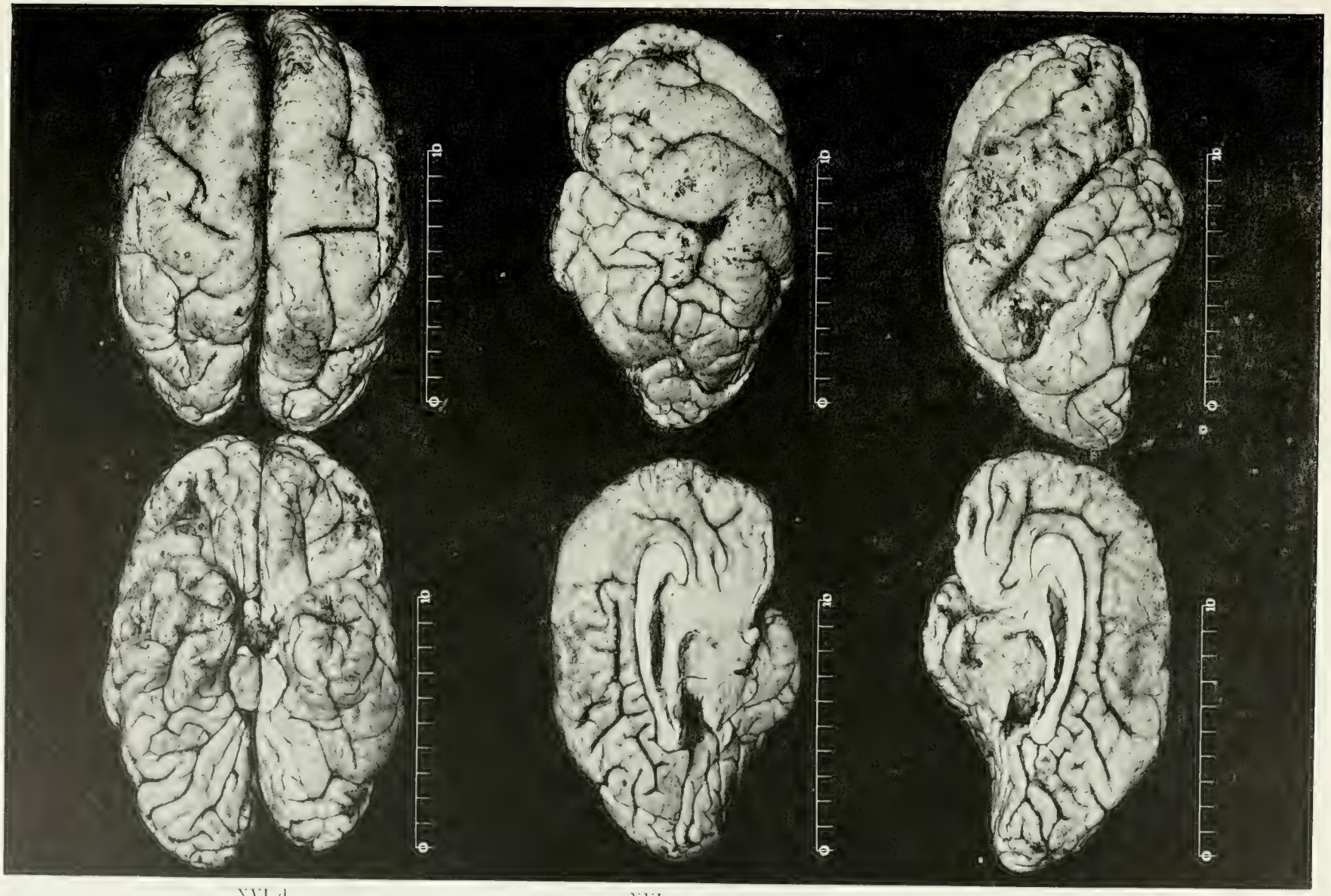
CASE XV — IMBECILE



CASE XV — IMBECILE

XV-o XV-p

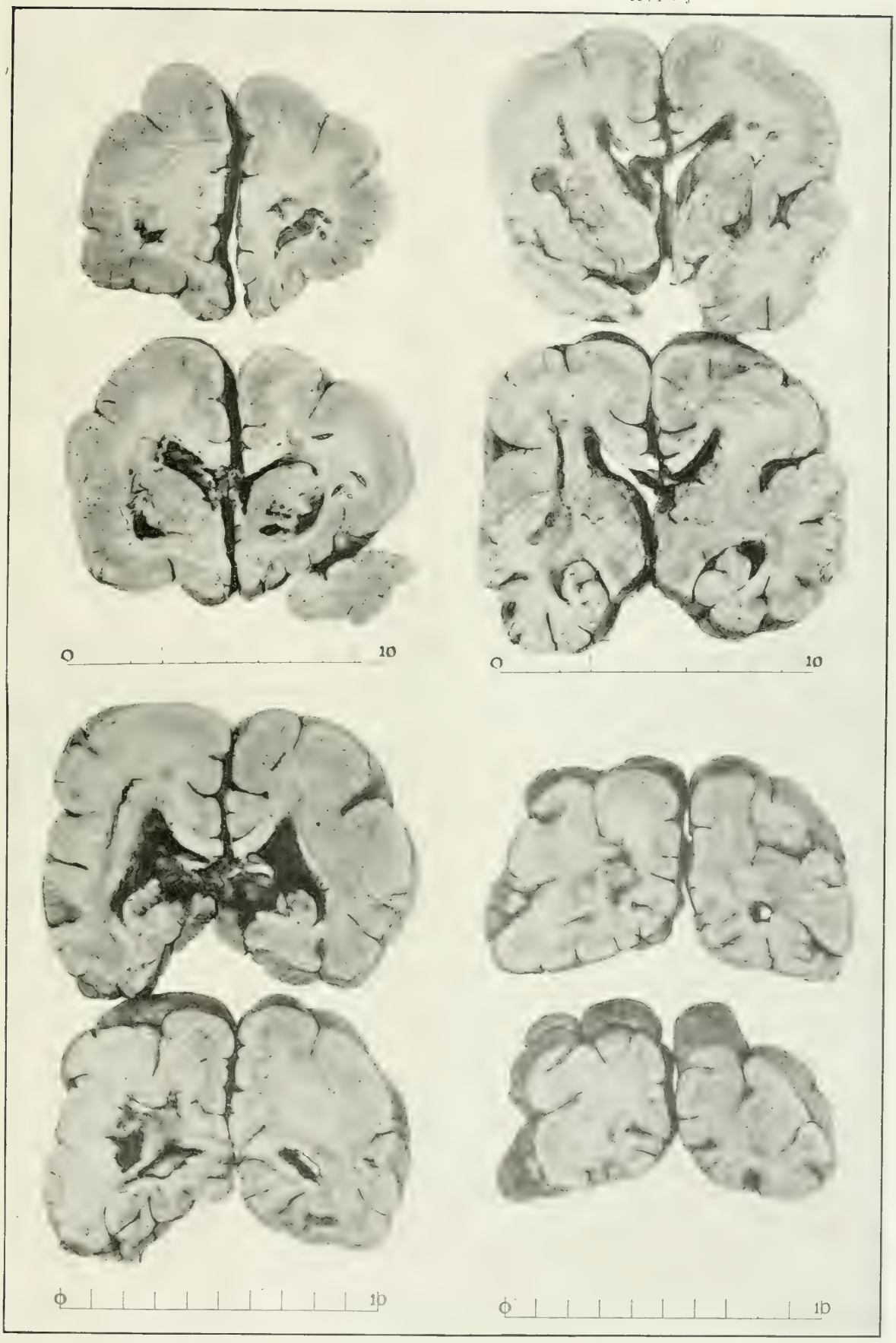
CASE XV — IMBECILE



CASE XVI MACROGYRIA

XVI-g-h

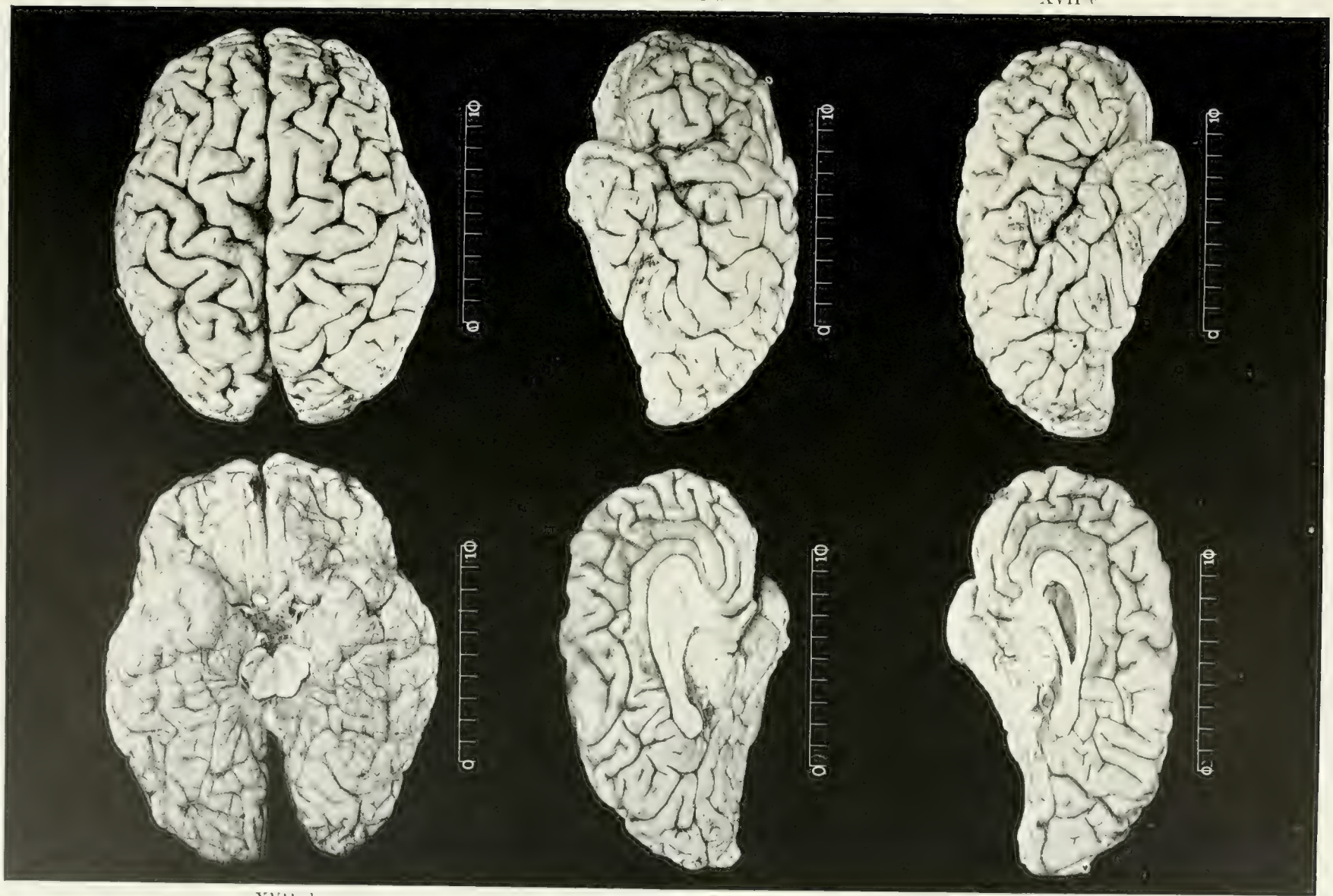
XVI : j



XVI-k-l

XVI-m-n

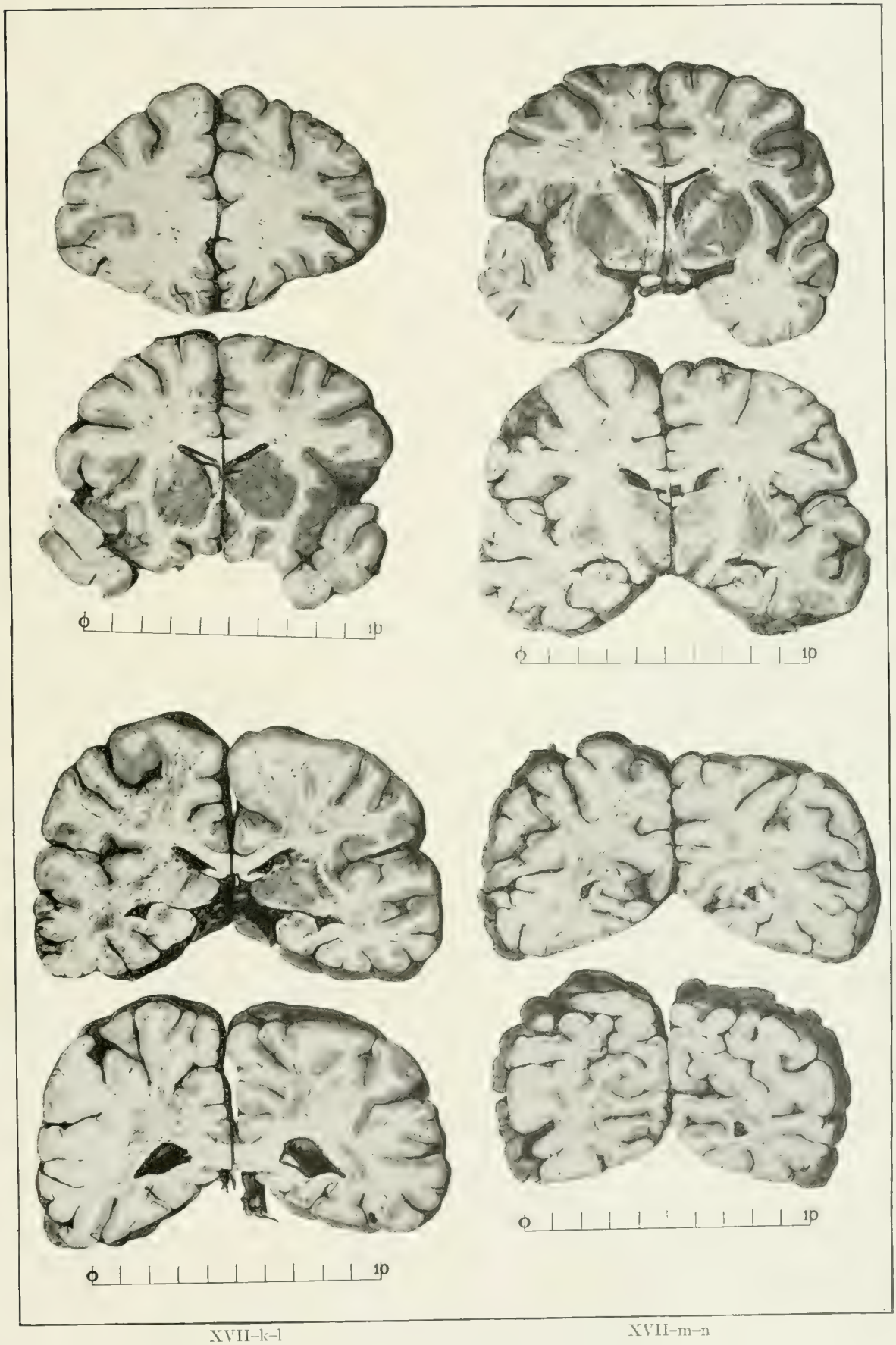
CASE XVI — MACROGYRIA



CASE XVII — IMBECILE

XVII g h

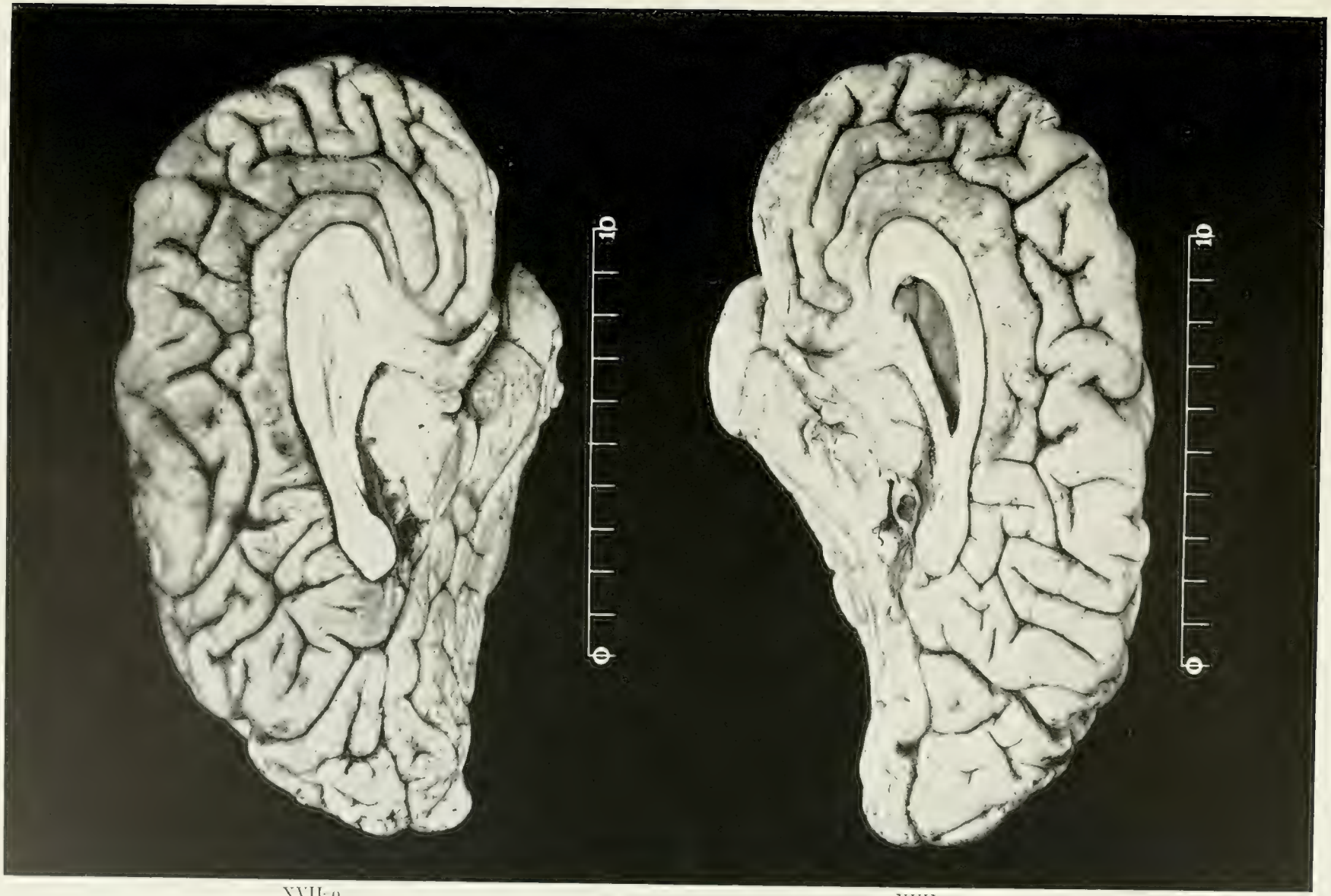
XVII i j



XVII–k–l

XVII–m–n

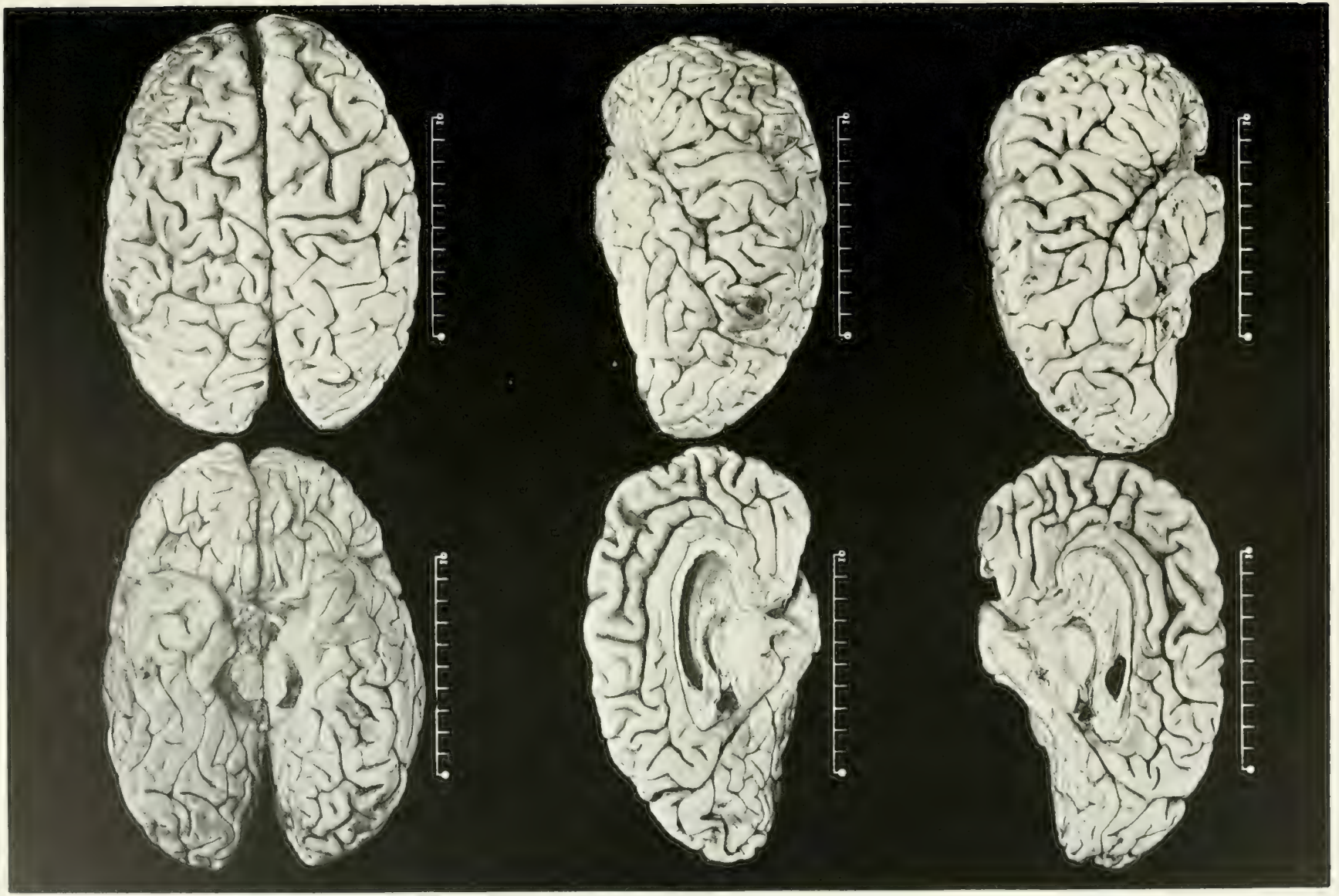
CASE XVII — IMBECILE



XVII-o XVII-p

CASE XVII — IMBECILE

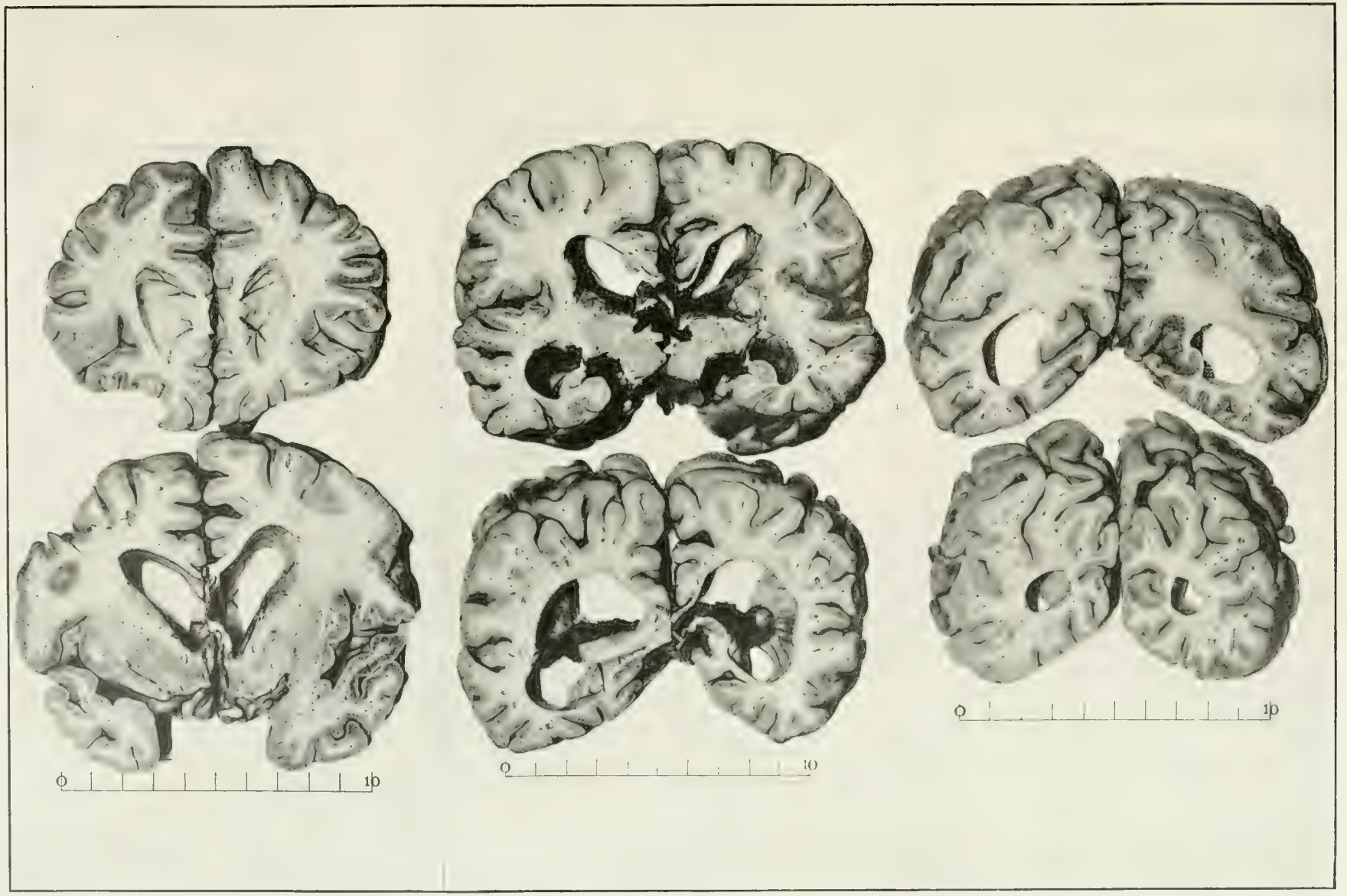
XVIII–a XVIII–b XVIII–c



XVIII–d XVIII–e XVIII–f

CASE XVIII — IDIOT

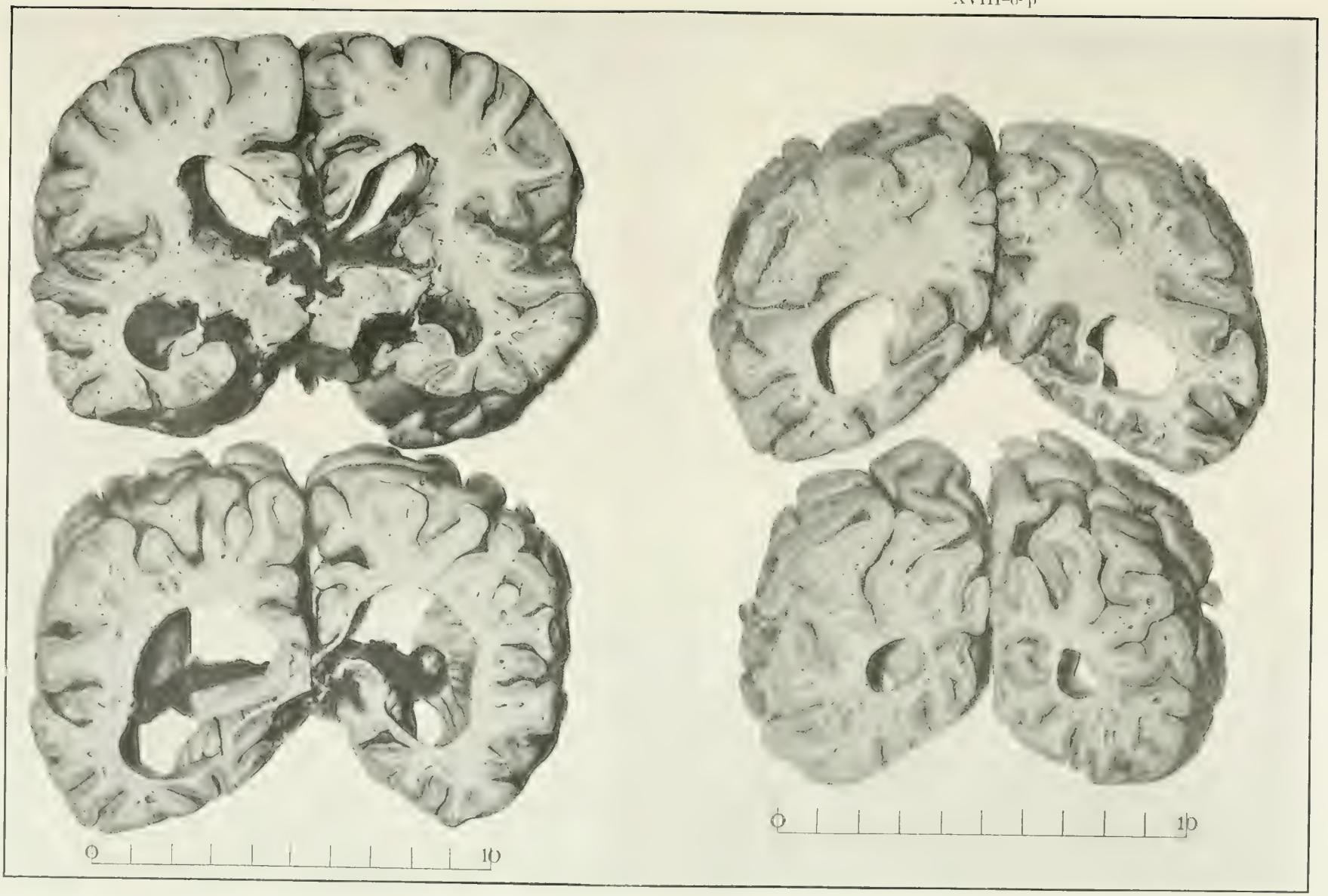
XVIII-g-h XVIII-i-j XVIII-k-l



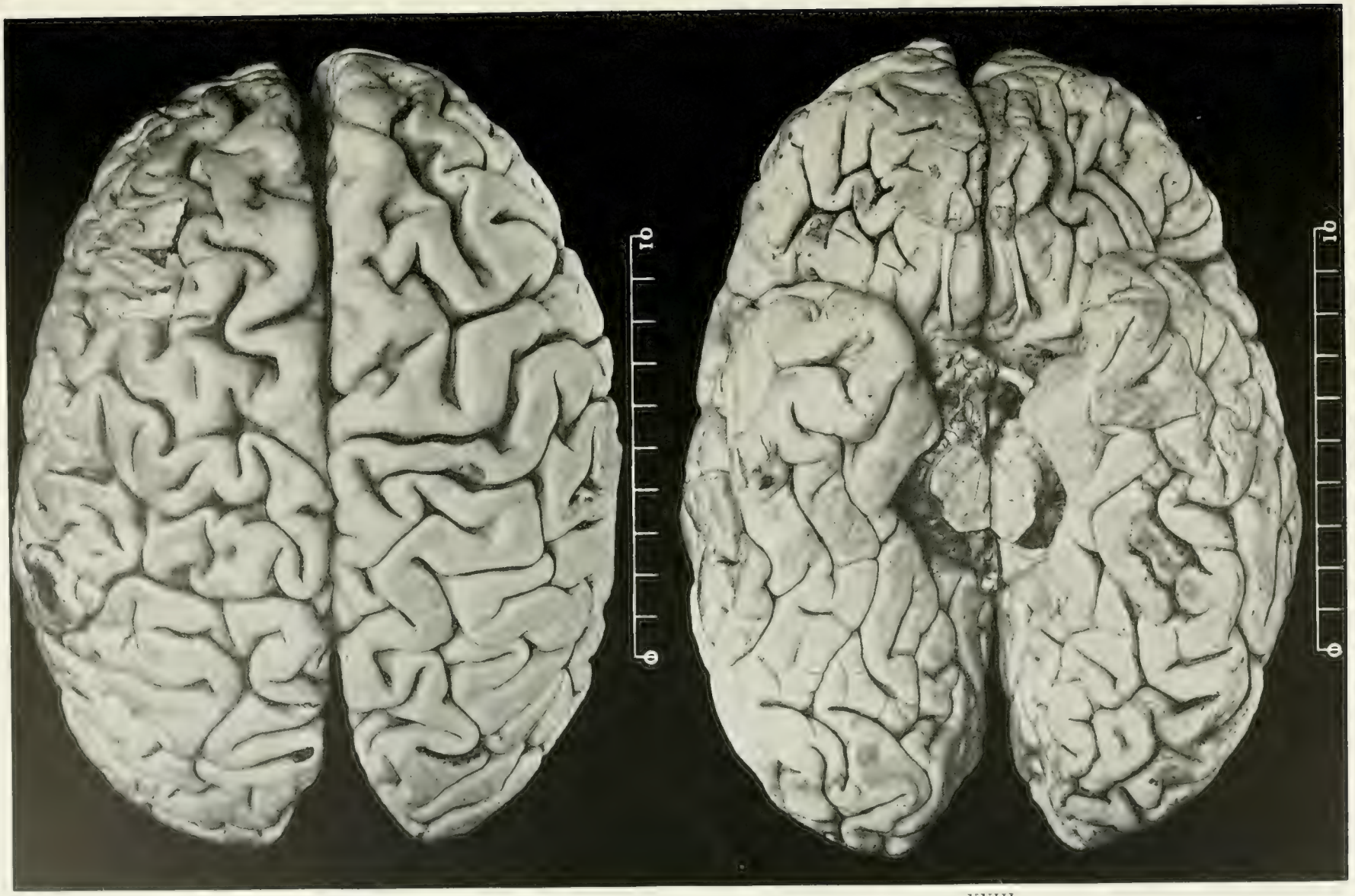
CASE XVIII — IDIOT

XVIII-m-n

XVIII-o-p



CASE XVIII — IDIOT



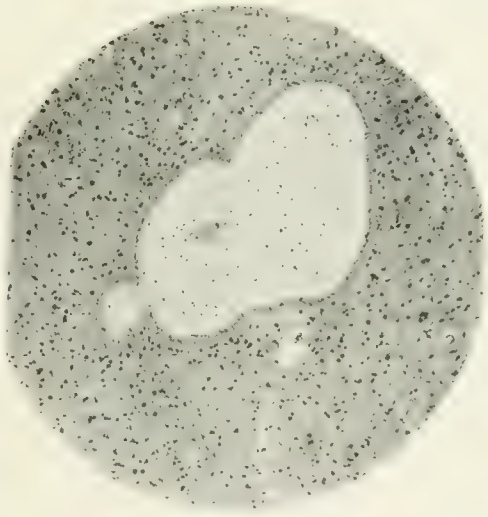
XVIII–q XVIII–r

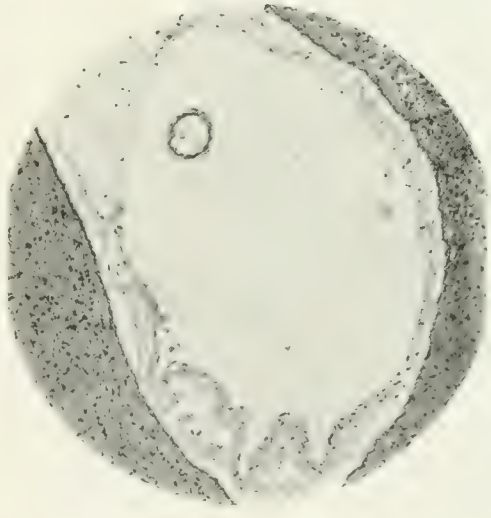
CASE XVIII — IDIOT

XVIII-s

XVIII-t

CASE XVIII — IDIOT

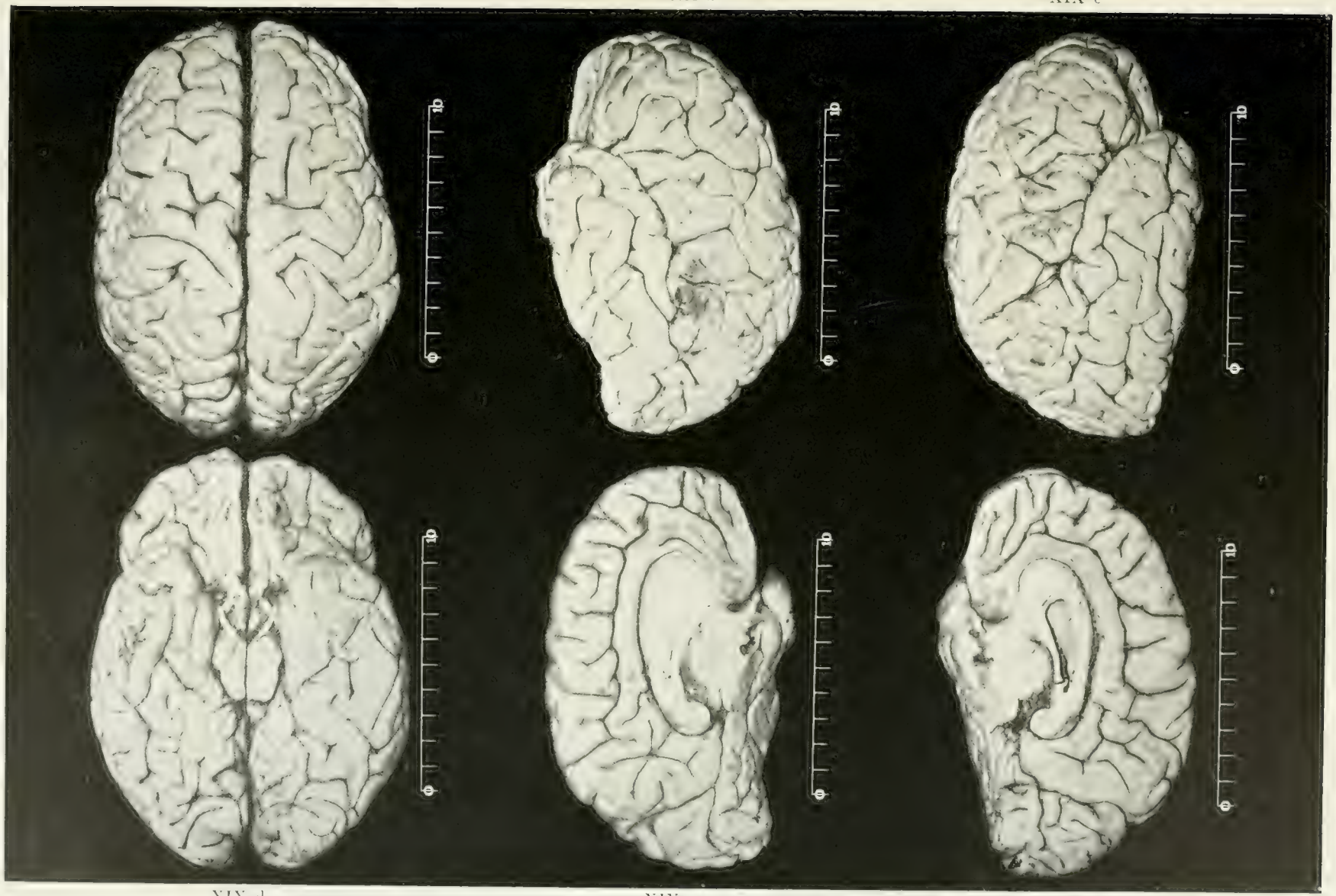




XVIII–v

XVIII–w

CASE XVIII — IDIOT



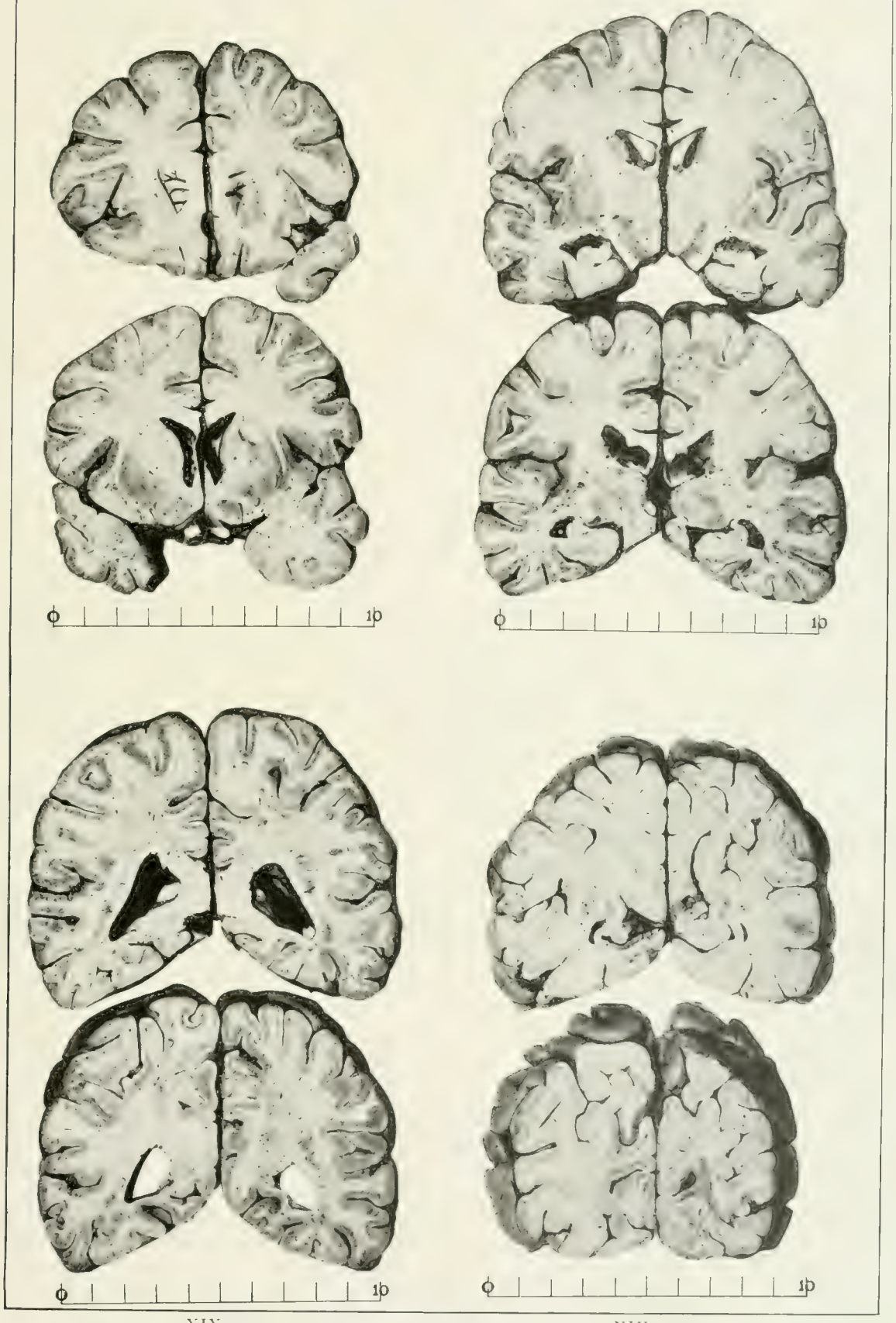
CASE XIX — MONGOLIAN

XIX–g XIX–h

CASE XIX — MONGOLIAN

XIX–i–j

XIX–k–l



XIX m–n

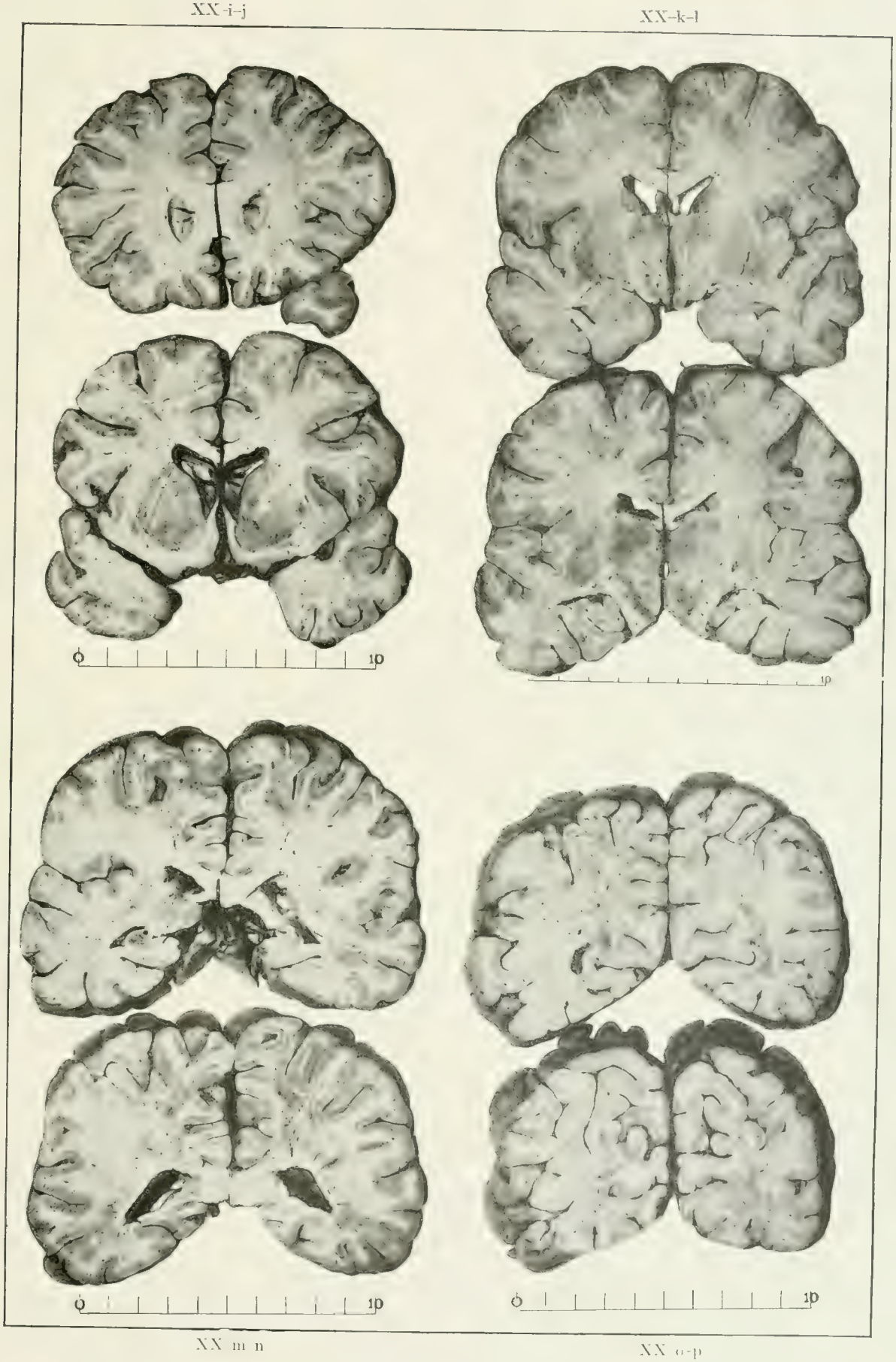
XIX–o p

CASE XIX — MONGOLIAN

CASE XX — INSANE IMBECILE

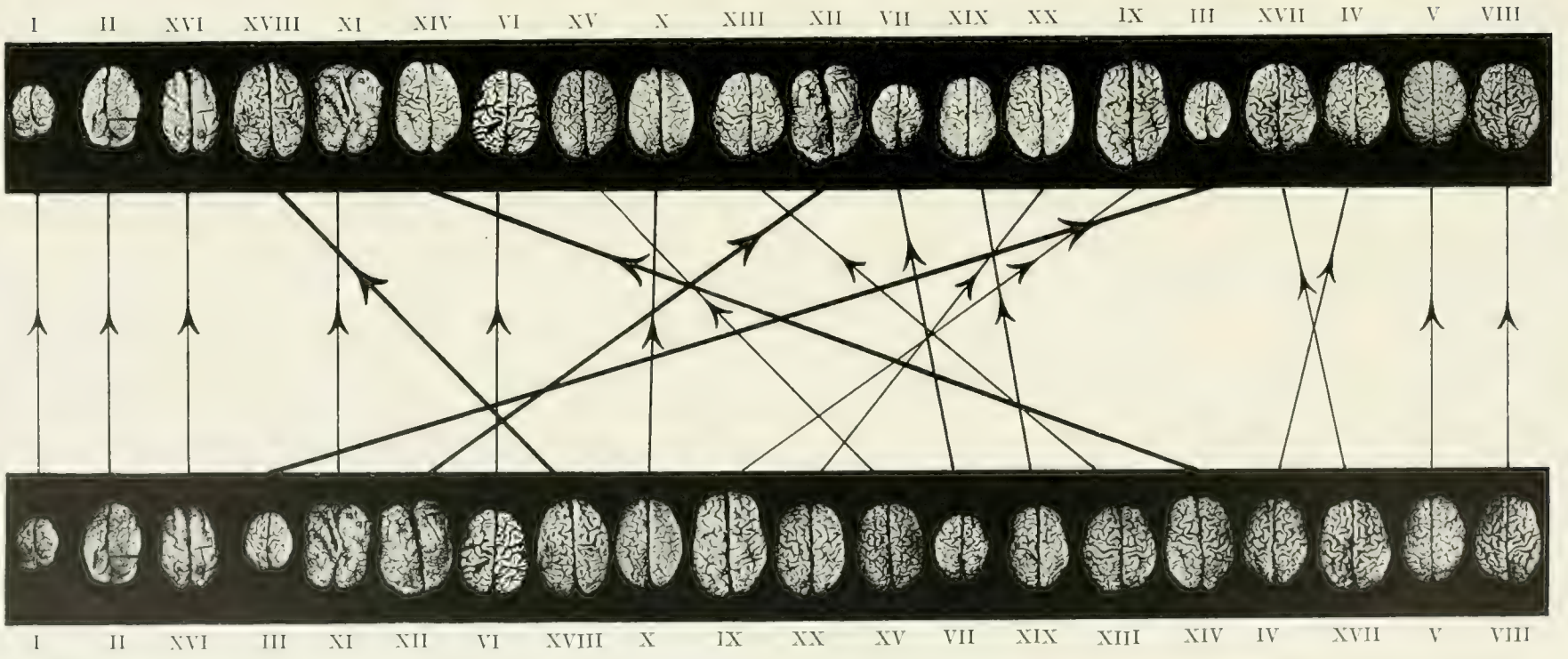
XX-g XX-h

CASE XX — INSANE IMBECILE



CASE XX — INSANE IMBECILE

INTELLECTUAL ORDER (Binet — See Table XI)


I II XVI XVIII XI XIV VI XV X XIII XII VII XIX XX IX III XVII IV V VIII
I II XVI III XI XII VI XVIII X IX XX XV VII XIX XIII XIV IV XVII V VIII

ANATOMICAL ORDER (Brain Complexity — See Table IX)

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OF

THE AMERICAN ACADEMY

OF

ARTS AND SCIENCES

VOL. XIV.—NO. IV

CAMBRIDGE:
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AUGUST, 1923

IV.

PHOTOMETRIC MAGNITUDES OF FAINT STANDARD STARS

MEASURED VISUALLY AT

HARVARD, YERKES, LICK AND McCORMICK OBSERVATORIES

BY

EDWARD C. PICKERING
J. A. PARKHURST
ROBERT G. AITKEN
HEBER D. CURTIS
S. A. MITCHELL
HAROLD L. ALDEN
T. McN. SIMPSON
F. W. REED

PREPARED FOR PUBLICATION BY

S. A. MITCHELL

INVESTIGATIONS ON LIGHT AND HEAT, PUBLISHED WITH AID FROM THE RUMFORD FUND.

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INTRODUCTION.

In discussing the condition of the measures on the faint standards with Professor E. C. Pickering about a year before his death, he asked if I would not be willing to act as editor and prepare the material for publication. Although the measures had been completed between the years 1902 and 1905, the final magnitudes had not been derived at the different observatories. The reason for this delay was that the magnitudes derived by Parkhurst with the twelve-inch refractor differed systematically from those obtained at Harvard by Professor Pickering to the extent of seven-tenths of a magnitude, the Yerkes magnitudes being brighter than those of Harvard. It seemed, therefore, wiser to derive the standards of twelfth magnitude by photovisual methods, and accordingly the reductions were delayed. These photovisual magnitudes have never been determined, and hence it has been necessary to complete the reductions using the magnitudes determined by Professor Pickering as the standards of reference. Both Aitken and Parkhurst at once completed their reductions and turned over to me their whole material. At the McCormick Observatory the matter was left in the hands of Harold L. Alden, who took complete charge of the reductions and devised the methods to be utilized. The earlier McCormick results incorporated in the following pages were taken from his dissertation submitted in partial fulfillment of the degree of Doctor of Philosophy.

The descriptions of the various phases of the work are practically in the same form as they were turned over to me by the participating observatories. The editor alone is responsible for the final magnitudes and the general conclusions drawn. He wishes to express his appreciation for the assistance and kind coöperation shown by Professors Pickering, Bailey, Parkhurst, Aitken and Shapley, but specially by his colleague Alden.

S. A. Mitchell.

The undersigned is unable to agree entirely with the views of the editor in ascribing so much error to the measures made with our twelve-inch refractor. By the reasoning given in the text these should be the best made at Yerkes, as the match was best between the real and artificial stars, and the conditions at the telescope were the most similar to those in the laboratory calibration of the wedge.

I have made an extensive set of measures with the wedge-photometer of the stars in the north polar sequence, and the work of determining the photovisual magnitudes of the twelfth magnitude standards at Yerkes is about half completed. When these measures appear in the *Publications of the Yerkes Observatory* they will furnish data for a more complete discussion of the scales of the wedges, and the magnitudes of the faint standards.

J. A. Parkhurst.

PHOTOMETRIC MEASURES OF FAINT STANDARD STARS.

Early in the year 1900, Professor E. C. Pickering inaugurated a plan of far-reaching importance whereby magnitudes photometrically determined should be extended to the faintest stars visible in the largest refractors of the world, the Lick thirty-six-inch and the Yerkes forty-inch. Five photometers of the equalizing wedge type were constructed by Alvan Clark and Sons, and it was planned to have these photometers identical in design, with their wedges cut from the same photographic plate.

In observing each of the regions selected, it was planned that five standard stars of the twelfth magnitude should be chosen at Harvard College Observatory and measured with the twelve-inch meridian photometer. Five stars of the fourteenth magnitude were to be measured with the fifteen-inch telescope at Harvard. Five stars of the fifteenth magnitude were to be selected and measured with the twenty-six-inch telescope of the Leander McCormick Observatory, and five stars of the sixteenth magnitude with the thirty-six-inch Lick and forty-inch Yerkes refractors.

If possible the stars were to be arranged in order of magnitude and designated as follows:

12th magnitude,	A, B, C, D, E
14th magnitude,	F, G, H, J, K
15th magnitude,	L, M, N, O, P
16th magnitude,	Q, R, S, T, U

The photometers were completed in April 1900, and were sent to the participating observatories. Five hundred dollars was granted by the Rumford fund to bear the cost of the photometers, to pay for record books, charts, etc., and also for a small compensation for observer and recorder in making the observations.

Choice of Standard Stars.

Thirty-six regions in the sky — hereinafter called Rumford regions — were chosen by Professor E. C. Pickering. These were to satisfy approximately the locations given in *Harvard Annals*, XIV, p. 477. Three regions were chosen having an average declination of $+75°$, nine with average declination $+45°$, twelve of declination $+15°$ and twelve of declination $-15°$.

The regions chosen contained groups of stars surrounding variables of long period,

which are very faint at minimum. Twelve regions were selected from Series I of Hagen's Atlas of Variable Stars, twelve from Series II, and twelve from Series III.

It was not a part of the plan that the faint standard stars should serve as comparison stars for the observation of the variable by the Argelander method. The instructions for the choice of standard stars were: "Select the stars when possible following the variable, and more than 5′ and less than 15′ distant from it. If too near, their apparent brightness will be affected when the variable is bright. Preference should be given to stars in the same declination as the variable and following it about 10′. A star should not be chosen if it is double, or if a bright star is near."

The stars of twelfth magnitude measured at Harvard were to serve as standard stars with which were compared the fainter stars of fourteenth, fifteenth and sixteenth magnitudes. Each observer was to measure the five standard stars of twelfth magnitude (S), and another series of five stars (F), of which three should be the faintest stars that could be measured with accuracy. On account of the greater uncertainty of measuring the faint stars, each observer was requested to measure each of the faint stars three times, and the twelfth magnitude stars twice, in the order F, S, F, S, F. Four photometric settings were to be made on each star. Similar series were to be measured on three nights.

The above plan was carried through with some modifications. The stars of the sixteenth magnitude in the twenty-four regions north of the equator were selected by Professor J. A. Parkhurst with the forty-inch Yerkes refractor. These twenty-four northern regions were the only ones measured with the forty-inch. Parkhurst departed from the original plan by making three settings on each star instead of four, and by measuring the faint stars twice instead of three times, and the bright stars once, or twice, but frequently on a greater number of nights. With the photometer attached to the twelve-inch refractor and six-inch reflector, he made measures connecting the twelfth magnitude standards with catalogue stars of the seventh magnitude.

Professor Robert G. Aitken measured all thirty-six regions with the thirty-six inch refractor of the Lick Observatory. He measured the stars selected by Parkhurst in the twenty-four northern regions, and chose for himself the stars for measurement in the twelve southern regions. Curtis, Townley and Stebbins participated in the measurements.

Stars of the fifteenth magnitude were selected and measured with the twenty-six-inch refractor at the Leander McCormick Observatory by Heber D. Curtis, then Vanderbilt fellow in astronomy at the University of Virginia. Curtis was the first of the observers to complete the assigned measurement, the time of the thirty-six-inch and forty-inch being largely taken up with other lines of investigation.

Little work was done at Harvard with the stars of the fourteenth magnitude for

these proved to be too faint to be measured with the fifteen-inch telescope. At Princeton, R. S. Dugan measured seventeen of the northern fields with the twenty-three inch refractor. These measures are not now available and, consequently, they are not included in the present discussion. In May, 1903, Professor Pickering wrote to Professor Ormond Stone asking if the stars of the fourteenth magnitude might not be measured at the Leander McCormick Observatory. Accordingly, the measures were made with the twenty-six-inch refractor by T. McN. Simpson and F. W. Reed, then Vanderbilt fellows at the University of Virginia, each observer measuring the sequence of stars on two nights.

When the work of measurement was started in 1900 each observer was furnished with Hagen charts for the regions under investigation. As none of the faint stars were found on these charts, each observer marked on the charts the stars chosen and sent to Professor Pickering their approximate coördinates, expressed as differences from the variable in right ascension and declination.

To assist in identifying the stars at the Lick telescope, photographs were made with the Crossley reflector which were enlarged to the scale of the Hagen charts. Professor Parkhurst made a complete series of photographs with the two-foot reflector of the Yerkes Observatory and had enlargements made on the scale of one millimeter equal to 10″. These photographs were sent to the observers who desired them, and they were of the greatest assistance in helping to identify the faint stars. The reproductions appearing in this publication are from the photographs made by Professor Parkhurst. The other observers are under great obligation to him.

Standards of 12th Magnitude.

The measurements of the twelfth magnitude standards were made at Harvard College Observatory by Professor E. C. Pickering. The following description of the methods employed was prepared by Professor Pickering himself. "A series of measurements of the light of the standard stars of the twelfth magnitude was made during the years 1901 and 1902 with the photometer attached to the 12-inch Horizontal Telescope of Harvard College Observatory. In this instrument the telescope is pointed to the west and a mirror placed in front of it reflects the light of any star on the meridian into the telescope as in the case of the four-inch meridian photometer. An artificial star is formed by reflecting the light of a Welsbach gas flame shining through a small hole into the field of view by means of a plane glass reflector placed near the focus of the telescope. The light of the star is varied by a wedge of shade glass closely resembling that used by Professor Pritchard in the Uranometria Oxoniensis (See *Harvard Annals*, XIII). As in the meridian photometer, a recorder brings the stars successively into the field, and records the settings made.

"The stars to be measured in the vicinity of each of the thirty-six Rumford regions consisted, first, of the five standard stars of the twelfth magnitude, secondly, of a brighter comparison star, and thirdly, of ten stars whose photometric magnitudes as determined by the four-inch meridian photometer are given in Table I of Volume XXIV.

"In selecting the ten stars from Volume XXIV, preference was given to those fainter than magnitude 8.00, and five were usually taken from the zone north, and five from the zone south of the standard stars. By this means the correction for atmospheric absorption becomes insensible. Five of the Rumford regions are south of declination $-20°$, and moreover, stars in the zone $-25°$ are not contained in Volume XXIV. Two of these regions, those around Z Sagittarii and S Aquarii are in declination so near $-20°$, that all of the standard stars have been selected from the zones $-19°$ and $-20°$. The stars R and S Scorpii are at declination $-22°\ 39'$ and $-22°\ 42'$, respectively, and the correction for differential absorption for each of the faint standard stars as compared with the stars selected from Volume XXIV is 0.05, according to *Harvard Annals*, XIV. The magnitudes of these have accordingly been corrected by that amount. In the region of R and S Scorpii only five stars have been taken from Volume XXIV, each being observed twice instead of once each evening. The declination of V Capricorni is $-24°\ 19'$, and a correction of 0.10 has been similarly applied.

"The stars in each region were observed on three evenings in the following order, four photometric settings being made on each star: The bright comparison star, the five twelfth magnitude standards, the bright comparison star, the ten stars from Volume XXIV, the bright comparison star, the five twelfth magnitude standards, and the bright comparison star. Each of the stars from Volume XXIV was observed once, the twelfth magnitude stars twice and the bright comparison star four times.

"To reduce the observations the magnitudes according to Volume XXIV were subtracted, for each of the stars contained in that work, from the observed magnitudes. The mean of these differences was then applied to the observed magnitudes of all the stars, and gave the photometric magnitude reduced to the scale zero-point of the four-inch meridian photometer. The results of these measurements are contained in Table I. The designation is given in the first column, taken from the Bonn Durchmusterung for stars contained in Volume XXIV, and using the Hagen number for the other stars. The differences from the variable in right ascension and declination are given in the second and third columns. The photometric magnitudes as determined with the horizontal telescope are given in the fourth column. The fifth column gives the residual found by subtracting the magnitude given in the fourth column from that contained in Volume XXIV, negative values being indicated by *Italics*. A positive sign therefore indicates that the

star was fainter according to Volume XXIV than according to the present series of measurements."

Attention should be called to the fact that the photometer used by Professor Pickering was not one of the five special photometers, and that its wedge was not photographic but was made from a shade glass. Although a careful search was made, no description was found of the methods used in calibrating the wedge, and it has accordingly been assumed that a "wedge constant" was employed to reduce the observations, or in other words that the absorption of the wedge increased uniformly with increase of wedge readings. The magnitudes of all stars in Table I were derived by Professor Pickering, and they are given without any change whatever. The results have already been published in *Harvard Annals*, Volume LXXIV.

Table I contains for each region, first the results of the ten stars of approximately ninth magnitude from *Harvard Annals*, Volume XXIV, then the bright comparison star, and finally the five stars of twelfth magnitude. The letters A, B, C, D and E were assigned to these twelfth magnitude standards in increasing order of their Hagen numbers and not according to the derived magnitudes.

The differences of right ascension and declination are referred to the position of the variable. The positions of the ten stars in the sequence for S Cassiopeiae were taken from the Greenwich Astrographic Catalogue. In other cases the positions were taken from the Astronomische Gesellschaft Catalogues for all stars contained therein. When these positions were given for 1875, Hagen's position of the variable for 1900 was carried back to 1875 by means of the precession constants on Hagen's charts. There were many exceptions to the above. Durchmustering positions were used for the sequence of RR Librae, R and S Scorpii, Z Sagittarii, V Capricorni, and S Aquarii, for which there were no Gesellschaft Catalogues. Also for the last star in the sequence of S Ceti, R Ceti, U Arietis, V Aurigae, T Virginis, U Virginis, S Bootis, R Draconis, S Herculis, R Aquarii, and the last two in the sequence of S Orionis and W Leonis; which are all fainter than the limit of the Gesellschaft catalogues.

The position of the bright comparison star in each sequence was taken from Hagen's Catalogues. The coördinates of the five stars of twelfth magnitude were derived from measures of photographs made at the Yerkes Observatory by Miss Harriet McW. Parsons. The method of deriving these positions will be explained later, (page 279).

TABLE I.

Twelfth Magnitude Standards.

S Ceti $0^h\ 18^m\ 58^s - 9^\circ\ 53'.0$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
− 9 49	−3 57	+ 0 16.3	8.93	*07*
− 9 53	−3 1	+ 0 13.0	8.76	*10*
−10 55	−2 54	+ 0 5.7	9.35	04
−10 58	−1 17	+ 0 6.2	8.09	07
−10 60	−1 15	+ 0 3.0	8.52	29
−15 49	−5 58	− 4 59.0	9.27	*02*
−14 58	−0 25	− 4 45.5	9.23	*12*
−14 59	−0 21	− 4 50.6	9.61	*10*
−15 60	−0 6	− 5 1.0	8.83	*03*
−15 70	+3 10	− 4 55.1	8.71	05
9	−0 35	+ 0 23.2	10.53	
	m s	′ ″		
23	+0 0.1	− 3 53	12.32	
24	−1 1.5	− 2 44	12.50	
25	+0 2.1	+10 10	12.67	
26	+0 35.8	+ 9 54	12.64	
27	−0 48.3	− 6 19	12.91	

U Cassiopeiae $0^h\ 40^m\ 46^s + 47^\circ\ 42'.6$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
+45 188	−1 56	− 2 20.3	8.77	00
+45 192	−0 26	− 2 21.7	8.89	*22*
+45 208	+2 57	− 2 27.2	8.98	*06*
+45 223	+6 1	− 2 26.9	8.50	*18*
+45 228	+7 14	− 2 26.1	8.29	*07*
+50 122	−6 3	+ 2 33.9	9.27	15
+49 191	+0 46	+ 2 23.9	8.56	06
+49 193	+1 14	+ 2 26.4	8.52	15
+49 227	+6 28	+ 2 30.9	9.27	10
+50 171	+6 43	+ 2 36.8	8.78	09
14	+1 46	+ 0 18.3	9.45	
	m s	′ ″		
54	+0 26.7	+ 4 48	12.24	
55	+0 3.5	+11 7	11.48	
58	+1 11.6	− 2 20	12 12	
60	+0 34.8	+ 2 49	12 07	
63	+0 14.6	− 3 7	12.40	

S Piscium $1^h\ 12^m\ 21^s + 8^\circ\ 24'.3$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
+ 5 140	−13 55	− 3 9.4	9.82	*06*
+ 4 178	−11 27	− 3 16.2	9.88	*08*
+ 5 165	+ 0 3	− 3 2.8	7.76	30
+ 4 232	+ 4 54	− 3 11.3	9.22	*01*
+ 4 249	+ 8 47	− 3 16.7	9.57	*07*
+10 148	− 3 47	+ 2 3.9	9.46	*09*
+ 9 139	− 3 28	+ 1 49.6	9.57	25
+10 152	− 2 13	+ 1 50 9	9.56	*04*
+10 161	+ 2 2	+ 2 1.7	8 72	*15*
+ 9 162	+ 5 44	+ 1 43 3	8 49	*02*
10	− 0 54	+ 0 7 8	10 94	
	m s	′ ″		
12	+ 0 28 8	−12 14	11.22	
13	− 1 13 1	− 4 45	11.59	
14	+ 0 50 2	+ 5 26	11 75	
15	+ 0 14 4	− 1 55	11.96	
16	+ 0 57 8	+11 51	12 50	

S Cassiopeiae $1^h\ 12^m\ 18^s + 72^\circ\ 5'.1$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
+70 81	− 9 31	− 1 42.6	9.51	*02*
+69 98	+ 9 24	− 2 2.5	8.85	*01*
+70 105	+ 9 39	− 1 40.7	8 54	*15*
+69 99	+10 28	− 1 59.2	9 21	29
+69 100	+11 15	− 2 1.0	8.71	08
+75 42	−31 8	+ 3 55.4	8.59	*12*
+76 25	−30 18	+ 4 21.1	8.80	07
+75 43	−29 0	+ 3 55.8	9.76	*29*
+76 31	−18 37	+ 4 14.0	8.41	*07*
+76 38	− 3 58	+ 4 11.3	8 97	10
5	− 5 15	− 0 7 2	8 82	
	m s	′ ″		
20	+ 3 8 7	+ 7 32	11 46	
22	+ 1 6 5	+13 47	11 64	
25	+ 2 21 9	+11 31	11 65	
27	+ 0 42 8	− 7 34	11 67	
35	− 0 4 3	− 4 33	12 44	

Twelfth Magnitude Standards.

R Ceti 2h 20m 55s −0° 37′.8 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
−1 309	−9 53	− 1 7.7	9.68	*21*
−1 318	−5 45	− 1 6.7	10.24	*22*
−0 360	−0 56	+ 0 48.8	8.02	26*
+0 396	−0 42	+ 1 45.8	9.00	09
−0 362	+0 26	+ 0 46.9	9.18	05
+0 404	+2 18	+ 1 40.0	8.60	*01*
+0 408	+3 15	+ 0 57.9	8.53	10
+0 414	+5 11	+ 1 42.1	8.43	*14*
−1 352	+6 8	− 1 0.3	7.87	25
+1 440	+6 53	+ 1 51.3	8.93	06
4	+1 9	+ 0 20.4	9.84	
	m s	′ ″		
14	+0 27.4	+13 43	12.03	
15	−0 22.4	+ 5 48	12.43	
17	+0 16.8	+12 45	12.60	
18	+0 51.8	+ 3 51	12.62	
20	+0 25.3	+11 56	12.93	

U Arietis 3h 5m 30s +14° 25′.3 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+10 408	− 7 25	− 4 7.2	8.31	*04*
+10 412	− 5 50	− 4 1.4	8.16	*14*
+ 9 398	− 2 23	− 4 21.4	9.57	*60*
+ 9 415	+ 3 7	− 4 20.3	8.63	*21*
+10 432	+10 24	− 4 8.8	8.64	*17*
+14 518	− 2 20	+ 0 33.0	7.99	15
+14 526	− 0 16	+ 0 32.9	8.63†	
+15 438	− 1 12	+ 0 52.5	8.67	42
+15 443	+ 0 14	+ 0 54.6	9.29	20
+15 459	+ 5 36	+ 0 52.6	9.04	*20*
+14 545	+ 6 7	+ 0 37.2	8.72	02
5	− 0 14	+ 0 20.2	9.79	
	m s	′ ″		
17	− 0 2.5	−11 2	12.60	
19	− 0 26.0	+ 8 20	13.04	
21	+ 0 34.1	+ 6 37	13.19	
22	+ 0 12.9	+ 2 58	13.08	
23	− 0 10.7	− 7 52	13.26	

R Persei 3h 23m 41s +35° 19′.6 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+34 652	−2 45	− 0 13.1	9.23	*11*
+34 678	+3 15	− 0 17.7	9.58	*38*
+35 719	+4 34	− 0 6.6	9.71	31
+34 682	+4 39	− 0 18.5	9.07	05
+35 723	+5 39	− 0 8.9	8.88	19
+39 784	−3 54	+ 4 46.6	8.14	*07*
+40 748	−3 35	+ 4 54.6	8.44	23
+40 762	−1 25	+ 4 58.4	8.85	*13*
+40 763	−0 52	+ 4 55.6	8.18	04
+39 818	+5 4	+ 4 42.1	8.79	*12*
11	−1 27	+ 0 12.1	10.04	
	m s	′ ″		
23	+0 41.0	+13 6	10.86	
33	+0 28.4	+ 4 45	11.84	
34	−0 16.3	+ 8 24	11.72	
35	−0 13.8	+ 6 36	11.78	
36	+0 0.6	+ 5 7	11.85	

V Tauri 4h 46m 15s +17° 22′.1 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+15 670	−8 55	− 2 4.3	8.11	03
+14 757	−4 12	− 2 21.5	9.06	*17*
+14 785	+3 26	− 2 19.5	9.32	*03*
+14 809	+9 5	− 2 17.5	9.16	*32*
+15 721	+9 30	− 2 15.8	8.08	21
+19 800	+0 25	+ 2 34.2	8.58	17
+20 838	+1 49	+ 2 46.7	9.74	*24*
+20 846	+3 0	+ 2 47.3	8.57	*07*
+20 855	+5 52	+ 2 47.7	8.07	28
+19 831	+7 15	+ 2 40.8	8.36	14
5	+0 35	− 0 12.3	9.24	
	m s	′ ″		
22	−0 17.3	− 8 49	12.44	
24N	+0 21.4	+ 9 52	12.52	
24S	+0 21.4	+10 0		
25	+0 12.0	+ 3 31	12.48	
27	+0 28.6	− 1 47	12.36	
30	+0 10.7	+ 9 54	12.44	

* In H. A., **24**, 11, for magn. 9.28 read 8.28.

† One measure only.

Twelfth Magnitude Standards.

S Orionis $5^h\ 24^m\ 5^s - 4^\circ\ 46'.4$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
−1 906	−0 59	+2 55.0	8.38	*11*
−1 909	−0 15	+2 55.7	8 69	*02*
−0 978	+1 34	+4 43.4	8.04	04
−0 981	+2 28	+4 48.7	8.33	05
−1 929	+2 33	+2 49.3	8.13	09
−4 1119	−3 35	−0 2.2	8.91	04
−4 1120	−3 31	+0 4.8	9.47	..
−5 1273	+0 55	−0 14.4	9.36*	*01*
−4 1155	+2 5	−0 6.6	8.38	22
−5 1285	+3 46	−0 15.6	8.73	*18*
−4 1175	+5 55	−0 3.6	8.81	*13*
20	−0 48	+0 21.3	9.64	
	m s	′ ″		
34	−0 29.2	+7 56	11.94	
35	+0 14.7	−1 12	11 56	
36	+0 27.4	−7 44	11.54	
37	+0 3.6	+3 5	12.12	
40	+0 57.9	−4 41	11.98	

V Aurigae $6^h\ 16^m\ 30^s + 47^\circ\ 45'.3$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
+44 1410	−6 9	− 2 51.9	8.90	12
+45 1288	−2 28	− 2 36.3	8.56	21
+44 1441	+1 38	− 2 51.3	9.35	12
+44 1445	+3 0	− 2 53.0	8.68	24
+44 1456	+5 26	− 2 47.7	8 71	*14*
+50 1294	−3 44	+ 2 15.9	9.39	*07*
+50 1300	−0 25	+ 2 19.8	9.21	*24*
+50 1301	−0 13	+ 2 18.8	8.67	05
+49 1499	+5 39	+ 2 4.6	9.25	*08*
+49 1511	+9 53	+ 2 10.6	9.14	*22*
7	−1 22	+ 0 16.7	9.41	
	m s	′ ″		
22	−0 17.9	− 6 46	11.64	
27	−0 17.6	−10 26	12.27	
30	−0 14.2	− 4 15	12.61	
31	−0 5.4	+ 7 44	12.35	
35	−0 13.5	+ 7 21	12.62	

R Geminorum $7^h\ 1^m\ 20^s + 22^\circ\ 51'.5$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
+20 1695	−1 58	− 2 53.1	8 76	*26*
+19 1600	−1 15	− 2 57.3	9 03	02
+20 1725	+3 22	− 2 53 5	7.99	*14*
+20 1729	+4 37	− 2 48.3	8.26	*41*
+20 1745	+7 27	− 2 49 3	9 04	01
+19 1659	+7 26	− 2 58 9	8.23*	*13*
+24 1512	−3 54	+ 1 54 7	9 18	*02*
+24 1532	+0 1	+ 1 57.6	9.28	28
+24 1549	+3 48	+ 1 58 3	8.05	16
+24 1554	+4 49	+ 1 57.8	9.24	12
+25 1625	+9 3	+ 2 12.8	8.93	23
6	+0 2	+ 0 5.8	9 13	
	m s	′ ″		
27	−0 32 8	− 9 14	11.93	
28	−0 18 0	− 7 55	11 46	
37	+0 7 4	−13 35	12 27	
38	−0 3 3	− 6 33	12 14	
14	+0 15 5	−10 28	12 84	

U Puppis $7^h\ 56^m\ 8^s - 12^\circ\ 33'.8$ (1900)

Desig.	$\Delta\alpha$	$\Delta\delta$	Magn.	Res.
°	m s	° ′		
−10 2329	−0 40	+2 25.8	9.03	13
− 9 2324	−0 34	+2 30.0	8.79	02
−10 2355	+2 28	+2 21.1	9.27	*01*
−10 2360	+2 59	+2 21.9	8.96	05
− 9 2351	+3 29	+2 31.4	8 37	*06*
−14 2309	−2 13	−2 24.2	8 60	11
−14 2340	+1 47	−2 31.0	9.00	*09*
−14 2341	+1 52	−2 25.9	8.95	01
−15 2211	+1 54	−2 36.1	9.02	*11*
−14 2348	+2 47	−2 30.5	9 00	*04*
2	+1 16	+0 2 7	8.01	
	m s	′ ″		
45	−0 25.6	+3 24	11.43	
47	−0 41 7	−3 56	. . .	
51	−0 3 2	−4 30	11.76	
53	+0 21 4	−4 16	11 13	
56	+0 6 6	−8 25	11 36	
82	−0 55	−3 24	12 23	

* One measure only.

Twelfth Magnitude Standards.

V Canceri 8 16 1 +17 36.1 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
□	m s	° ′		
+14 1873	−2 19	−2 44.1	9.30	*06*
+15 1800	−0 26	−2 34.8	9.07	07
+15 1803	+0 6	−2 41.0	9.47	07
+15 1804	+0 17	−2 40.5	9.47	*13*
+14 1878	+0 14	−2 58.1	7.91	*02*
+20 2045	−3 21	+2 18.9	8.46	*21*
+19 1979	−1 47	+2 9.7	8.98	*03*
+19 1988	−0 41	+2 10.0	9.17	23
+19 1990	−0 26	+2 11.4	9.48	07
+19 1991	+0 2	+2 12.2	8.68	*03*
+20 2081	+4 2	+2 19.7	8.99*	*09*
8	−0 15	+0 23.4	9.16	
	m s	′ ″		
24	+0 17.5	+0 20	11.33	
26	+0 36.2	−6 14	11.74	
27	−0 36.4	+0 58	12.05	
38	+0 5.4	+7 59	12.59	
39	+0 26.7	+8 14	12.55	

T Hydrae 8 50 48 −8 45.6 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
− 4 2470	−5 0	+3 44.4	8.89	*09*
− 4 2475	−4 9	+3 44.1	8.92	*37*
− 5 2655	−2 19	+3 32.3	9.12	*02*
− 5 2670	+1 49	+3 27.8	9.22	03
− 5 2671	+2 4	+3 31.6	8.98	*08*
− 9 2671	−5 29	−1 14.7	9.48	13
−10 2685	−1 28	−1 46.9	8.10	21
−10 2690	−0 38	−1 50.7	7.56	10
− 9 2701	+1 52	−0 56.8	7.66	20
− 9 2718	+5 23	−1 20.7	9.53	*02*
14	−1 2	+0 21.0	9.75	
	m s	′ ″		
24	+0 32.2	−0 6	11.42	
25	−0 28.1	+9 28	11.91	
27	−0 38.4	−1 29	12.29	
29	−0 20.9	−3 8	12.13	
30	+0 45.4	+2 37	12.16	

R Leonis Minoris 9 39 35 +34 58.3 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
□	m s	° ′		
+35 2036	−4 40	− 0 8.6	9.17	00
+35 2039	−3 44	+ 0 3.4	8.55	*38*
+35 2043	−2 46	− 0 9.0	8.75	12
+35 2059	+2 35	− 0 5.2	9.59	28
+39 2272	−3 42	+ 4 43.8	8.84	*12*
+40 2248	−1 53	+ 4 54.6	9.52	*16*
+40 2261	+4 28	+ 4 7.7	6.74	18
+40 2270	+7 23	+ 4 50.2	9.38	*11*
+39 2289	+9 21	+ 4 45.1	9.45	00
9	+1 28	− 0 7.4	9.13	
	m s	′ ″		
26	+0 34.4	+ 4 21	12.29	
27	−1 9.5	−10 56	12.63	
29	+0 16.1	− 5 47	13.03	
30	+0 22.9	− 5 35	12.97	
31	−0 46.2	− 8 13	13.35	

W Leonis 10 48 21 +14 14.9 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
+ 9 2417	−2 40	−4 31.3	9.68	*21*
+10 2212	−2 20	−4 29.3	7.92	*10*
+ 9 2418	−2 15	−4 34.2	7.66	06
+ 9 2423	−1 34	−4 39.4	8.18	*21*
+ 9 2434	+5 4	−4 34.6	9.81	*19*
+15 2246	−6 30	+0 30.6	9.81	03
+14 2299	−5 35	+0 29.3	8.23	*04*
+14 2301	−4 3	+0 28.8	9.64	15
+15 2251	−3 42	+0 33.7	8.46	28
+14 2313	+1 9	−0 0.7	11.36	*28*
9	−0 24	−0 14.4	10.48	
	m s	′ ″		
20	+0 57.2	−5 38	12.30	
22	+0 50.8	+2 21	12.32	
23	+0 34.3	−7 15	12.72	
24	+0 16.8	−2 14	12.71	
27	+0 17.1	−8 32	12.88	
31	−0 23	−8 42	13.20	

* One measure only.

Twelfth Magnitude Standards.

T Virginis 12h 9m 29s −5° 28′.8 (1900)

Desig.	Δα	Δδ	Magn.	Res.
	m s	° ′		
−4 3214	−6 2	+0 16.8	9.60	20
−5 3432	−5 58	+0 11.6	9.49	06
−5 3444	−3 17	+0 6.8	8.07	18
−5 3459	+0 57	+0 5.9	8.33	07
−4 3250	+4 48	+0 17.0	8.79	06
−10 3403	−7 40	−4 52.2	9.82	*06*
−9 3434	−7 14	−4 42.2	8.24	*13*
−9 3452	−3 28	−4 40.2	8.90	*14*
−9 3456	−3 5	−4 42.8	9.36	*15*
−9 3483	+5 35	−4 45.7	8.52	*01*
−10 3451	+6 27	−4 52.2	9.61	*10*
10	+1 39	−0 9.4	10.10	
	m s	′ ″		
18	+0 46.7	−13 53	11.62	
19	+0 37.9	+3 16	11.46	
22	+0 17.8	−7 55	12.21	
23	−0 11.4	−14 4	12.25	
24	+0 14.2	−6 43	12.24	

T Ursae Majoris 12h 31m 50s +60° 2′.3 (1900)

Desig.	Δα	Δδ	Magn.	Res.
	m s	° ′		
+60 1381	−25 40	−0 11.6	9.63	03
+60 1389	−19 17	−0 13.7	9.19	12
+60 1408	+0 58	−0 16.8	8.93	01
+60 1421	+13 13	−0 8.4	8.86	*20*
+59 1468	+14 22	−0 26.2	8.93	03
+64 894	−11 55	+4 37.4	8.33	*08*
+64 895	−11 44	+4 33.1	9.25	00
+64 909	+1 3	+4 35.2	9.16	04
+65 892	+1 38	+4 48.0	9.56	*11*
+65 906	+14 55	+4 44.1	9.03	17
13	+2 27	+0 1.2		
	m s	′ ″		
20	−0 32.8	+1 57	12.51	
21	+0 56.5	−3 54	12.71	
22	−0 4.4	−12 16	13.31*	
23	−0 39.3	−13 48	13.39	
24	+0 4.5	+8 29	13.24	
26	+0 14.6	+14 23	13.15	

U Virginis 12h 46m 1s +6° 5′.8 (1900)

Desig.	Δα	Δδ	Magn.	Res.
	m s	° ′		
+5 2669	−8 50	−1 15.3	7.98	*07*
+4 2648	−5 37	−1 33.0	9.28	02
+5 2673	−5 43	−1 10.9	9.46	*15*
+5 2690	+2 34	−1 18.9	7.83	08
+4 2685	+10 10	−1 35.5	9.64	*04*
+9 2675	−2 44	+3 33.6	8.12	*15*
+9 2676	−2 19	+3 38.3	8.70	22
+10 2474	−1 29	+3 49.3	7.72	10
+10 2484	+3 48	+3 46.1	9.46	*14*
+9 2694	+5 33	+3 36.1	8.60	12
9	−0 8	−0 23.1	10.05	
	m s	′ ″		
15	+0 59.1	+5 25	11.22	
16	+0 23.6	+0 35	11.39	
17	+0 47.0	−1 6	12.19	
18	−0 58.7	+1 23	12.63	
19	−0 16.6	−9 2	13.00	

S Virginis 13h 27m 47s −6° 40′.8 (1900)

Desig.	Δα	Δδ	Magn.	Res.
	m s	° ′		
−5 3694	−6 5	+1 16.1	8.03	*08*
−5 3715	−0 59	+1 25.7	9.28	*13*
−4 3506	+0 31	+1 32.0	8.75	*10*
−5 3735	+4 16	+1 18.0	8.60	00
−4 3527	+6 16	+1 29.9	8.95	00
−9 3702	−3 27	−3 30.9	8.27	*06*
−9 3719	+1 47	−3 24.8	8.79	27
−10 3712	+2 25	−3 42.5	8.74	07
−9 3726	+3 7	−3 29.6	9.27	*06*
−10 3718	+3 51	−3 42.6	9.24	02
6	+0 50	−0 5.4	9.55	
	m s	′ ″		
18	+0 7.7	+11 16	12.06	
19	−0 43.3	+6 22	11.97	
20	−0 55.5	+13 30	12.31	
22	−0 49.5	+8 33	12.92	
24	−0 14.8	+4 5	12.95	

* One measure only.

Twelfth Magnitude Standards.

S Bootis 14 19 32+54 15.9 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
+54 1637	−23 55	+ 0 21.7	8.52	14
+55 1649	−21 44	+ 0 35.5	8.92	*01*
+54 1653	−10 52	+ 0 26.9	9.04	02
+55 1686	+ 6 2	+ 0 41.2	8.91	*10*
+54 1701	+21 43	+ 0 28.5	8.97	*11*
+59 1555	−18 17	+ 5 27.1	9.20	06
+60 1507	−17 59	+ 5 34.7	9.38	13
+59 1560	−13 11	+ 5 22.1	9.12	*01*
+59 1566	− 8 18	+ 5 26.8	8.98	*17*
+59 1575	− 3 16	+ 5 29.8	8.52	09
9	− 1 55	− 0 0.0	10.28	
	m s	′ ″		
21	+ 1 8.8	+ 7 38	12.30	
22	− 0 4.0	+ 3 55	12.40	
23	− 1 9.0	− 6 18	12.64	
24	− 1 8.8	+14 30	12.84	
25	+ 0 15.9	− 4 22	12.84	

R Camelopardalis 14 25 6+84 17.1 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
+84 269	−136 19	− 0 13.6	8.08	03
+84 274	−128 34	− 0 21.4	7.78	33
+84 276	−124 22	− 0 18.1	8.10	18
+84 303	− 73 42	+ 0 25.4	9.43	*25*
+84 322	− 3 30	+ 0 7.1	8.35	21
+84 324	+ 5 20	+ 0 14.7	9.95	00
+84 329	+ 16 35	+ 0 27.2	9.88	*15*
+84 348	+ 74 33	+ 0 33.2	8.79	*01*
+84 352	+ 95 1	+ 0 35.1	8.20	*17*
4	+ 7 35	− 0 6.6	9.35	
	m s	′ ″		
13	+3 58.3	+ 5 47	11.55	
14	+8 39.7	+ 7 47	12.49	
16	−4 44.1	+12 7	12.29	
18	−6 45.4	+11 36	12.54	
19	+6 22.1	+ 3 33	12.43	

R Serpentis 15 46 5+15 26.3 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ″		
+14 2936	−3 56	− 0 37.6	9.13	*09*
+14 2943	−1 56	− 0 44.1	8.86	13
+15 2919	+0 12	− 0 27.6	8.76	*17*
+14 2956	+3 31	− 0 34.3	9.41	*17*
+15 2929	+4 35	− 0 32.4	8.56	03
+19 3012	−4 53	+ 4 24.5	9.51	04
+20 3144	−4 35	+ 4 28.1	8.92	08
+20 3154	−0 29	+ 4 33.7	8.24	*09*
+19 3033	+3 36	+ 4 16.1	8.43	22
+19 3038	+5 48	+ 4 16.8	9.06	*11*
7	+1 20	− 0 5.2	9.28	
	m s	′ ″		
15	−0 27.8	− 6 43	11.36	
16	−0 42.1	−11 51	11.24	
17	−0 37.8	− 3 19	11.59	
20	−0 49.0	+ 3 43	12.21	
21	−0 36.2	+ 6 1	12.29	

RR Librae 15 50 39−18 0.7 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
−14 4284	−7 16	+2 54.3	9.82	29
−14 4316	+0 43	+2 57.9	9.41	15
−15 4226	+2 1	+2 49.2	8.12	*11*
−15 4230	+4 30	+2 52.3	8.90	16
−15 4236	+6 22	+2 48.7	9.51	10
−19 4248	−3 41	−1 59.3	10.14	*66*
−19 4253	−2 37	−2 0.4	8.64	*06*
−20 4363	+0 7	−2 7.6	8.48	*10*
−19 4276	+3 30	−2 7.2	9.34	*21*
−20 4379	+4 4	−2 9.7	9.42	*24*
6	−0 6	−0 18.3	9.65	
	m s	′ ″		
17	−1 3.9	−3 27	11.61	
18	−0 40.4	−1 4	11.58	
19	−0 3.6	+8 26	11.51	
21	−0 56.8	−5 40	11.76	
22	−0 14.0	+6 52	11.59	

Twelfth Magnitude Standards.

R and S Scorpii 16h 11m 42s −22° 40′.4 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
−20 4423	− 6 32	+2 32.8	8.90	03
−19 4342	− 2 50	+2 41.5	9.03	10
−19 4346	− 2 3	+2 41.5	9.95	*67*
−19 4361	+ 2 59	+2 47.8	7.27	*13*
−20 4509	+15 22	+2 32.9	9.60	03
22	+ 0 3	+0 20.1	10.86	
	m s	′ ″		
26	+ 0 29.8	−3 21	11.81	
27	+ 0 40.6	+5 58	12.00	
29	+ 0 52.2	−3 15	12.09	
35	+ 0 14.9	+4 20	12.34	
38	+ 0 48.4	+1 30	12.29	

W Herculis 16h 31m 41s +37° 32′.4 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+34 2771	−14 12	− 2 39.6	9.38	14
+35 2830	− 3 17	− 2 30.5	9.23	09
+35 2856	+ 6 55	− 2 29.6	8.51	16
+35 2859	+ 7 43	− 2 32.9	9.12	05
+35 2869	+13 3	− 2 28.0	10.30	*28*
+40 3020	− 6 31	+ 2 27.6	8.70	17
+39 3003	− 4 57	+ 2 16.8	9.94	10
+39 3017	+ 0 47	+ 2 12.4	9.05	*18*
+39 3021	+ 3 2	+ 2 14.1	6.79	03
+39 3027	+ 6 38	+ 2 17.8	9.78	*31*
7	+ 1 40	− 0 26.6	9.08	
	m s	′ ″		
19	+ 0 22.7	− 1 1	11.51	
20	− 0 45.5	− 9 55	11.62	
21	+ 0 59.3	−14 1	11.33	
22	+ 1 46.3	− 8 33	11.96	
24	+ 1 31.4	− 0 46	12.20	

R Draconis 16h 32m 23s +66° 57′.8 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+65 1112	−14 41	− 1 56.7	9.37	*07*
+65 1123	− 3 46	− 1 53.5	8.56	19
+65 1125	− 2 21	− 1 58.6	9.13	12
+65 1127	− 0 21	− 2 3.5	9.22	18
+65 1140	+10 19	− 1 59.0	9.78	*13*
+70 881	− 4 51	+ 2 56.7	9.71	*17*
+70 882	− 3 39	− 1 0.0	8.97	*18*
+69 853	+ 0 10	+ 2 43.5	9.34	*05*
+69 854	+ 0 19	+ 2 54.8	9.97	22
+69 862	+ 6 51	+ 2 53.5	9.18	*09*
9	− 2 49	+ 0 2.8	9.52	
	m s	′ ″		
18	+ 0 27.8	− 9 30	11.12	
19	− 0 4.1	−10 11	11.82	
20	− 0 22.8	−11 21	12.20	
21	− 2 20.7	−10 56	12.38	
22	+ 1 48.4	+ 0 39	12.67	

S Herculis 16h 47m 21s +15° 6′.6 (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+15 3042	−8 44	− 0 6.2	8.03	21
+15 3060	−1 2	− 0 6.0	8.96	*17*
+15 3070	+1 10	− 0 3.5	8.16	28
+14 3143	+3 36	− 0 18.2	9.21	*07*
+14 3153	+5 27	− 0 13.5	8.73	11
+20 3325	−7 51	+ 4 55.1	8.90	*50*
+19 3166	−2 28	+ 4 21.7	8.32	*07*
+20 3343	+1 0	+ 4 54.3	10.06	*21*
+19 3195	+5 15	+ 4 42.9	9.89	*14*
+19 3211	+9 46	+ 4 48.2	9.05	30
8	+1 32	+ 0 2.3	10.53	
	m s	′ ″		
15	+0 40.1	−11 17	11.25	
16	+0 50.6	− 3 1	11.41	
17	+0 22.4	− 7 59	11.61	
18	+0 15.8	− 6 19	12.07	
21	+0 24.9	−12 14	11.66	

Twelfth Magnitude Standards.

R Aquilae 19h 1m 33s +8° 4.8′ (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+ 5 4021	−2 22	−2 59.1	8.37	*16*
+ 4 3976	+0 14	−3 10.3	8.71	*11*
+ 5 4032	+0 22	−2 59.6	8.28	*02*
+ 4 3987	+2 5	−3 7.2	8.56	14
+ 5 4043	+2 41	−2 51.8	8.82	04
+10 3768	−3 17	+2 14.4	8.30	02
+10 3782	−1 4	+2 11.2	8.86	*04*
+10 3785	+0 10	+2 6.9	8.82	10
+10 3794	+2 8	+2 8.4	8.27	15
+ 9 4004	+4 18	+1 54.8	8.82	*10*
12	−0 0	−0 17.9	9.28	
	m s	′ ″		
24	−0 11.8	+5 28	11.52	
26	+0 54.1	+3 11	11.67	
29	−0 53.0	+6 17	11.85	
31	−0 34.5	+6 24	11.70	
33	−0 55.0	−9 47	12.16	

Z Sagittarii 19h 13m 47s −21° 6.6′ (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		—
−20 5454	−5 38	+1 1.5	9.26	07
−20 5459	−4 59	+1 1.7	9.26	*13*
−19 5380	−1 52	+1 18.5	9.09	*21*
−20 5481	−1 44	+1 3.8	9.12	16
−19 5392	−0 50	+1 12.4	8.82	11
−20 5508	+1 45	+1 1.9	9.25	*07*
−20 5519	+3 20	+1 4.0	9.33	*05*
−19 5427	+4 8	+1 14.1	9.02	21
−19 5434	+4 46	+1 11.7	8.61	*23*
−20 5566	+9 8	+1 10.4	8.99	09
7	+0 7	+0 18.2	9.33	
	m s	′ ″		
25	−0 20.2	−5 10	10.59	
27	−0 45.6	−2 1	10.93	
29	−0 55.3	−5 33	10.78	
30	−0 16.8	−2 8	11.51	
35	+0 27.4	+5 6	11.63	

χ Cygni 19h 46m 44s +32° 39.7′ (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+29 3743	−3 30	−2 36.9	9.28	*02*
+30 3743	−3 13	−2 28.8	8.97	*06*
+30 3747	−2 59	−2 24.3	9.27	04
+30 3793	+1 59	−2 33.0	8.98	18
+30 3803	+3 36	−2 23.2	8.78	23
+35 3780	−5 37	+2 34.0	9.46	01
+34 3710	−3 25	+2 21.8	8.83	*06*
+34 3719	−2 23	+2 19.5	9.10	*23*
+34 3742	−0 18	+2 20.4	9.11	01
+35 3830	+0 32	+2 29.1	8.74	*07*
7	−0 31	−0 16.8	8.33	
	m s	′ ″		
59	+0 23.4	−2 9	10.73	
63	+0 39.4	+0 19	11.17	
64	+0 28.1	+3 45	11.23	
67	+0 14.8	+2 34	11.16	
81	+0 2.7	+7 36	11.25	

R Vulpeculae 20h 59m 56s +23° 25.5′ (1900)

Desig.	Δα	Δδ	Magn.	Res.
°	m s	° ′		
+20 4803	−3 22	−3 12.3	9.10	*08*
+19 4605	−1 49	−3 23.2	8.98	02
+20 4822	+0 8	−2 56.3	8.33	00
+20 4826	+1 1	−3 5.7	8.34	*21*
+19 4618	+1 34	−3 24.4	8.86	*08*
+25 4430	−5 9	+1 48.6	9.18	*03*
+24 4307	−1 5	+1 43.2	8.88	02
+24 4320	+1 1	+1 36.4	9.16	*10*
+25 4463	+2 11	+1 50.6	8.11	28
+24 4333	+4 46	+1 42.4	9.15	14
5	+0 43	−0 20.7	8.95	
	m s	′ ″		
23	+0 48.2	+4 54	10.51	
24	+0 33.8	+5 9	10.39	
25	−0 18.2	+4 11	10.83	
26	+1 1.9	+4 2	11.02	
29	−0 15.2	−6 56	10.72	

Twelfth Magnitude Standards.

V Capricorni 21 1 47 −24 19.3 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
−20 6093	− 7 28	+ 4 20.2	8.86	07
−19 5999	− 4 17	+ 4 37.4	8.44	*11*
−20 6131	− 0 8	+ 4 26.6	8.88	*05*
−19 6061	+ 8 59	+ 4 33.5	9.26	*08*
−20 6172	+ 9 38	+ 4 26.1	9.22	06
−20 6173	+ 9 51	+ 4 24.0	8.37	*24*
−20 6192	+14 2	+ 4 21.4	8.62	*04*
−19 6083	+14 44	+ 4 40.0	8.90	13
−19 6084	+15 1	+ 4 34.0	9.34	04
−19 6099	+19 55	+ 4 33 8	8.06	22
2	+ 0 55	− 0 17.4	7.64	
	m s	′ ″		
9	+ 0 21 1	− 7 7	10.58	
14	+ 0 43.1	− 2 18	11.20	
16	− 0 13.8	−23 31	11.24	
18	+ 0 47.8	+ 7 48	11 48	
19	+ 0 12 3	−20 29	11.33	

R Lacertae 22 38 50 +41 50.9 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
+39 4886	−8 24	− 1 37.9	8.60	*20*
+40 4871	−4 4	− 1 26.6	8.75	17
+40 4884	−1 42	− 1 28.1	9.20	07
+40 4929	+8 43	− 1 32.1	8.71	16
+39 4954	+9 14	− 1 40.4	8.99	18
+44 4193	−3 15	+ 3 13.4	8.76	*04*
+44 4210	+0 4	+ 3 22.4	9.43	*06*
+45 4035	+0 38	+ 3 32.1	9.61	*29*
+44 4224	+2 43	+ 3 13.8	8.87	05
+45 4066	+6 15	+ 3 24.3	9.66	*04*
11	+2 4	− 0 11.7	9.35	
	m s	′ ″		
45	+1 19.0	+ 9 47	11.76	
51	+0 23.7	− 3 44	12.35	
52	+0 35.4	−11 41	12.39	
54	+1 25.5	+ 5 20	12.50	
56	−0 12 4	+ 3 1	12.40	

S Aquarii 22 51 45 −20 52.6 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
−19 6328	−12 37	+ 1 16.0	9.46	*03*
−19 6337	− 9 36	+ 1 11.3	8.42	04
−19 6341	− 8 18	+ 1 15.8	9.31	03
−20 6504	− 2 10	+ 1 2.2	8.77	*09*
−19 6383	+ 4 8	+ 1 8.9	9.29	*11*
−20 6530	+ 5 44	+ 0 57.7	8.98	*10*
−20 6533	+ 6 20	+ 1 1.6	8.34	14
−19 6395	+ 7 53	+ 1 14.7	8.81	22
−19 6404	+11 0	+ 1 7.7	8.92	*14*
−19 6411	+12 39	+ 1 10.5	9.61	12
4	− 1 12	− 0 11.4	8.62	
	m s	′ ″		
16	− 0 50.7	+15 59	11.03	
17	+ 0 34 3	−10 58	11 10	
19	+ 0 36 8	+12 9	11.91	
20	− 0 22 1	−12 35	11 75	
21	− 0 20 4	−10 32	12 01	
23	− 0 1	− 8 5	12 84	

R Pegasi 23 1 38 +10 0.2 (1900)

Desig.	Δ α	Δ δ	Magn.	Res.
°	m s	° ′		
+ 5 5120	−3 53	− 4 42.9	9.57	*01*
+ 4 4956	−0 44	− 4 53.2	9 28	*03*
+ 4 4957	−0 33	− 4 52.6	9.29	11
+ 5 5140	+3 12	− 4 42.9	9 32	*06*
+ 4 4970	+3 32	− 4 52.8	10 06	*21*
+ 9 5149	−5 16	+ 0 14.4	9.13	*06*
+10 4877	−1 22	+ 0 21.7	9.11	11
+10 4899	+5 56	+ 0 24.2	7.92	10
+ 9 5181	+6 28	+ 0 7.3	9.10	*03*
+ 9 5184	+8 1	+ 0 11 1	9.16	06
3	+1 39	+ 0 2.1	8.55	
	m s	′ ″		
17	−0 31.5	− 4 49	11 48	
19	+0 9.1	+14 6	12.10	
20	+0 42.4	− 0 37	11 93	
21	+0 20.5	− 4 39	11 88	
23	+0 53.8	+11 38	12 29	

The Wedge Photometer.

On account of its simplicity and convenience the wedge photometer was the earliest form to be successfully used. The extinguishing form of wedge photometer, however, was subject to large systematic errors which could not be controlled even by an experienced observer. Professor Pickering, therefore, very happily devised the equalizing form, by substituting the wedge for the polarizing prisms in the older Zöllner photometer.

The wedge photometer has two great advantages over the polarizing form, and one apparent disadvantage. On account of the reflection and absorption of a large amount of light by the polarizing prisms it is possible to measure with a given telescope fainter stars with a wedge photometer than with one of polarizing form. Herein lies the great advantage of the wedge photometer — its measurement of stars approximately one magnitude fainter. A second advantage lies in the possibility of making the wedge practically uniform, so that a given motion of the wedge will correspond to a uniform change in the magnitude of the artificial star.

The disadvantage arises from the necessity of calibrating the wedge in stellar magnitudes. This disadvantage, however, is more apparent than real since the law of absorption of the polarizing prisms [1] has not been accepted without laboratory tests. The calibration of the wedge therefore rests on a basis similar to the laboratory checks used with the polarizing prisms, and the absorption of the wedge expressed in stellar magnitudes can be determined with a precision equal to that of the prisms. When this has once been accomplished, the measures made with the equalizing wedge photometer are much more readily turned into stellar magnitudes without the disadvantage of the uncertainty in the law of absorption to be used in the reductions.

The following brief description and illustration of the wedge photometer at Yerkes Observatory is by Parkhurst, *Astrophysical Journal*, **13**, 250, 1901. As already mentioned, the other four photometers are practically identical with the one used at Yerkes.

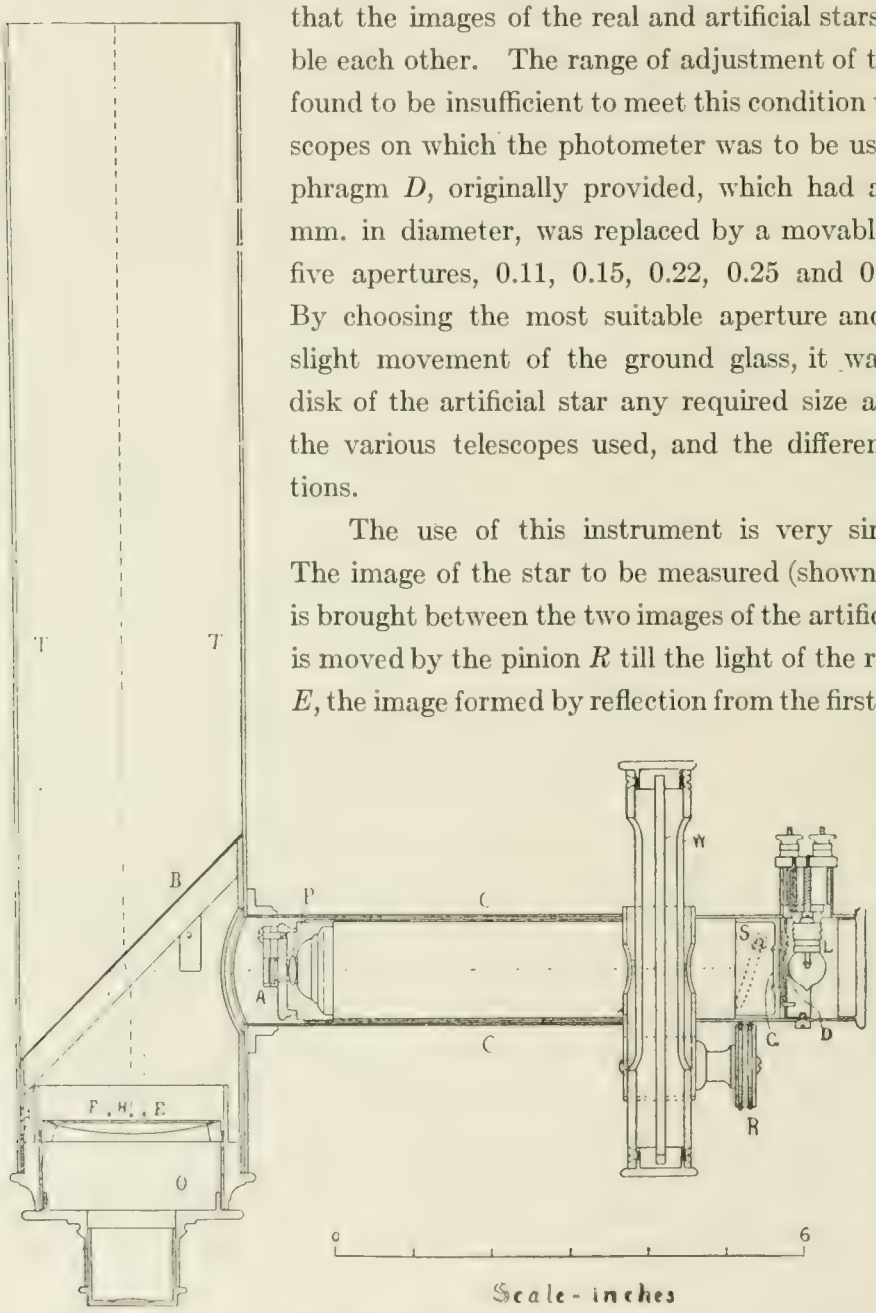
The construction of the instrument is shown in Fig. 1 and will need but few words in description. The tube T, carrying the ocular O, slides into the tailpiece of the telescope. At right angles to this is the tube C, carrying the essential parts of the photometer. The light from a $1\frac{1}{2}$ candle-power incandescent lamp L shines through a minute hole in the diaphragm D upon a piece of ground glass G, forming an artificial star. In contact with G is a piece of blue glass to render the light of the star less yellow. An image of this star is thrown by the projecting lens P upon a plate of plane-parallel glass B and reflected from both surfaces into the focus of the ocular O, forming at E and F two images of the artificial star. Interposed in the path of these rays is the photographic wedge W, movable at right

[1] Wilsing, *Astronomische Nachrichten*, **197**, 253, 1913.

angles to C by the rack and pinion R. The short tube carrying the ground glass G is movable away from the diaphragm D by means of the head of the screw S, projecting through an inclined slot in the farther side of the tube C. By this means the artificial star can be made larger and less sharply defined, thus resembling more closely a real star under poor atmospheric conditions. Finally, a pair of shade glasses at A can be moved, either both or singly, into the path of the rays.

In photometers made on this principle the all-important condition to be fulfilled is that the images of the real and artificial stars should closely resemble each other. The range of adjustment of the ground glass G was found to be insufficient to meet this condition with the different telescopes on which the photometer was to be used; therefore the diaphragm D, originally provided, which had a single aperture 0.17 mm. in diameter, was replaced by a movable diaphragm carrying five apertures, 0.11, 0.15, 0.22, 0.25 and 0.29 mm. in diameter. By choosing the most suitable aperture and combining with it a slight movement of the ground glass, it was possible to give the disk of the artificial star any required size and sharpness, to suit the various telescopes used, and the different atmospheric conditions.

The use of this instrument is very simple and convenient. The image of the star to be measured (shown at H in the drawing) is brought between the two images of the artificial star and the wedge is moved by the pinion R till the light of the real star is matched by E, the image formed by reflection from the first surface of the plate B. The position of the wedge is then read on a scale divided to twenty-fifths of an inch, tenths of a division being estimated. If now the light of a star of known magnitude be measured, the only unknown quantity is the absorption of the wedge expressed in magnitudes.



THE RUMFORD PHOTOMETER.

Measures at Yerkes Observatory.

The forty-inch refractor was used by Professor J. A. Parkhurst to measure the magnitudes of the stars of sixteenth magnitude, comparing them by means of the Rumford photometer with the standard stars of twelfth magnitude. The five faint standards in the twenty-four Rumford regions north of the celestial equator were selected by Parkhurst.

In each case three photometric settings constituted a measure. Each of the five faint stars was measured twice, or frequently three times, and each of the five bright standard stars of twelfth magnitude was measured once, or occasionally twice. Each region was measured on at least three nights.

Since the calibration of the wedge is fundamental for photometer measures it was thoroughly investigated by Parkhurst in no less than five different ways so as to eliminate any systematic errors which might be present in a single method of calibration. Three of the methods depend on comparisons with two different kinds of polarizing apparatus, two of the methods use the principle of the rotating sector. It was not practical to use the method of the inverse square of the distance as the artificial stars were used in focus and a change in the distance of the source was liable to change the appearance as well as the brightness of the image of the artificial star. Wedge V was used. Each of the five methods of calibration was carried out in the laboratory and not at the telescope. A preliminary discussion of this wedge is given in *Astrophysical Journal*, **13**, 249, 1901, and a more complete discussion is found in *Researches in Stellar Photometry*, 1906.

The five methods employed by Parkhurst were as follows: First, the absorption of the wedge was compared with that of a polarizing photometer kindly loaned by Professor Comstock of the Washburn Observatory, and which is described in detail in *Popular Astronomy*, **5**, 117, 1897. This Zöllner photometer was set up in a dark room opposite the wedge photometer, and the artificial stars were equalized, first by projecting the wedge star into the Zöllner and taking readings on the circle of the Zöllner for various settings on the wedge, and secondly, by reversing the photometers and projecting the Zöllner star into the wedge photometer.

The third method depends on cutting down the light of the artificial star by a rotating sector. The first sector used, called A, was made by two concentric circular discs, and the aperture was varied by turning these discs on each other. It was possible to fasten the circles securely in sixteen different positions with angles ranging from 4° to 181°. These angles were carefully measured on the table of the Fuess Spectrometer by Parkhurst and by Alden. When calibrating the wedge by this sector the light of the artificial star was passed through the sector rotated by a motor and projected into the wedge photometer

so as to take the place of a real star at the telescope. This sector star was formed in a manner precisely similar to the artificial star of the photometer, that is, the light passed through a small hole in a metal diaphragm, a piece of ground glass, and a piece of the same blue glass used with the photometer star. The two stars could not be distinguished in appearance from each other in these calibration measures. For this reason considerable confidence is felt in the resulting calibration of the wedge.

The fourth method employed is a slight variation from the third, a different rotating sector being utilized. This was kindly loaned by Dr. Harvey Brace Lemon, and is described by him in *Astrophysical Journal*, **39**, 209, 1914. It consists of a single piece of sheet brass with four petals. Each side of each petal is cut in steps, there being nine steps on all of the petals, besides three steps cut on three, two, and one petal respectively. The angles subtended by these steps were measured on the Fuess Spectrometer. The calibration with this sector (called "Lemon Sector") was carried out in the same manner as with sector A.

In each of the four methods outlined, the arrangement for the artificial stars was precisely like the conditions at the telescope, the images compared were in focus, the only difference being in the methods of cutting down the light of one star by a measurable amount. The wedge was also calibrated by means of the Brace spectrophotometer in the Ryerson Laboratory of the University of Chicago. However, as this spectrophotometer is arranged for comparing surfaces it was necessary to use a brighter lamp and to project the light of the photometer star, thrown slightly out of focus, as an area on the slit of the spectrophotometer. The matching of the areas in this instrument can be done with a somewhat greater precision than in the comparison of focal images. Whether systematic differences exist between the comparison of points and surfaces could only be decided by a comparison of the results. One difference certainly existed, that is, the projecting lens took in a larger cone of light from the wedge, and, therefore, tended to smooth out any small irregularities which might exist in the absorption of the wedge. This effect is visible when the calibration curve is compared with those obtained from focal images.

In Table II are given the results of the calibration of Wedge V by the five different methods. The initial letters in the first column indicate:

A	comparison with aluminum sector, A.
B	comparison with the Brace spectrophotometer.
L	comparison with Lemon sector.
W – Z	comparison with wedge-star projected into Zöllner.
Z – W	comparison with Zöllner star projected into wedge.

Columns 2 and 3 give the individual values of s, the scale reading and the corresponding difference in magnitude, ΔM. In column 4 and 5 are given group means of these quantities. A smooth curve was drawn through these points, the average slope of the curve being such that one division of the photometer scale corresponds to 0.107 stellar magnitudes. In column 6 are given the residuals for the different methods as compared with the curve. The residuals are taken in the sense, *Method* minus *Curve*. The average of the 52 residuals is ± 0.06 magnitudes; or, omitting the last value under Z−W, which is evidently anomalous, the average of the 51 is ± 0.05 magnitudes.

TABLE II.

CALIBRATION OF THE YERKES WEDGE.

Method	s	ΔM	Means s	Means ΔM	Resid.	Method	s	ΔM	Means s	Means ΔM	Resid.
B	5.8	0.02				W-Z	30.0	2.61			−.12
W-Z	7.1	0.13			−.07	B	30.1	2.82			+.08
B	8.3	0.23			−.13	A	32.0	2.88			−.05
L	9.3	0.41			+.02	Z-W	32.9	3.05			+.04
Z-W	10.3	0.47	9.4	0.39	−.03	L	33.3	3.12	32.9	3.01	−.05
B	11.0	0.51			−.06	B	34.8	3.19			−.03
L	11.2	0.58			−.07	W-Z	35.0	3.10			−.15
L	12.4	0.76			−.02	Z-W	35.4	3.30			+.02
L	13.7	0.91			.00	A	36.3	3.34			−.05
B	14.1	0.95			+.01	Z-W	39.5	3.67			−.03
A	14.4	1.09			+.10	W-Z	40.0	3.67			−.08
W-Z	15.2	1.05			−.07	B	40.6	3.76			+.01
Z-W	15.2	1.12	15.4	1.14	.00	L	41.2	3.84	41.2	3.85	−.01
L	15.4	1.10			−.03	A	42.8	4.14			+.07
L	16.3	1.31			+.07	Z-W	44.5	4.16			−.04
L	18.7	1.56			+.04	W-Z	45.0	4.18			−.07
B	18.7	1.62			+.09	B	46.5	4.40			.00
Z-W	18.9	1.63			+.08	A	49.4	4.77			+.07
A	19.4	1.64			−.02	W-Z	50.0	4.70			−.06
W-Z	20.5	1.80			+.07	L	50.3	4.65			−.15
Z-W	20.8	1.84	20.7	1.79	+.05	B	52.0	5.13	52.2	4.96	+.18
A	21.4	1.85			+.01	Z-W	52.4	4.79			+.31
L	21.7	1.89			+.03	B	56.7	5.43			
A	23.8	2.04			.00	B	60 0	5.83			
Z-W	24.1	2.12			−.03						
W-Z	25.0	2.18			−.04						
B	25.2	2.27			+.03						
A	26.3	2.26			−.04						
L	26.5	2.37	26.6	2.35	.00						
Z-W	26.8	2.37			−.02						
Z-W	29.4	2.68			−.02						
A	29.5	2.53			−.14						

The employment of so many different methods of calibration would seem to eliminate systematic errors, and the small values of the residuals indicate a satisfactory control of the accidental errors. Consequently, one feels justified in placing considerable confidence in the final results of this calibration. It is open to question whether any of the polarizing photometers in use have their reduction constants determined with enough greater accuracy to compensate for the larger accidental errors in setting at either end of the scale.

Table III gives the values read from the calibration curve, by means of which the photometric measures made with the forty-inch refractor were reduced.

TABLE III.

Scale	Magn.	Scale	Magn.	Scale	Magn.
1	0.00	21	1.82	41	3.88
2	0 00	22	1.92	42	4.00
3	0.00	23	2.02	43	4.11
4	0.00	24	2.11	44	4.21
5	0.06	25	2.20	45	4.32
6	0.12	26	2.29	46	4.43
7	0.19	27	2.38	47	4.53
8	0.27	28	2.47	48	4.63
9	0.35	29	2.56	49	4.73
10	0.45	30	2.66	50	4 82
11	0.57	31	2.76	51	4.91
12	0.69	32	2 87	52	5 00
13	0.81	33	2 98	53	5 08
14	0.94	34	3 09	54	5.16
15	1.07	35	3.20	55	5.22
16	1 20	36	3.32	56	5 28
17	1 33	37	3 43	57	5 34
18	1 46	38	3 55	58	5 39
19	1 59	39	3.67	59	5 44
20	1.71	40	3 77	60	5.49

All measurements with the forty-inch refractor at Yerkes Observatory were made by Professor J. A. Parkhurst, the results being given in Table IV. These include eighty-seven series on twenty-four stars, or an average of 3.6 series per star. The Yerkes photometer was supplied with two neutral tinted shade glasses absorbing 0.86 and 0.88 stellar magnitudes, respectively. Either or both of these shade glasses could be interposed in the cone of rays forming the real stars, but not in the path of light from the artificial stars. Most of Parkhurst's measurements were made without the use of shade glasses, but sometimes one and occasionally two shades were utilized when measures were being made on the bright standards, those of the twelfth magnitude.

From the values given in Table IV one can reproduce all of the essential details of the measurements, even including the mean readings of the wedge for bright and faint stars. In Table IV, Mo represents the stellar magnitude corresponding to the reading of zero on the photometer scale. As an example of the use of these tables, take those of the star U Cassiopeiae on the date of 1905, September 23, where Mo equals 10.27. The observed magnitude of star A is 12.17. $\Delta M = 1.90 = 12.17 - 10.27$. From Table III the wedge setting corresponding to $\Delta M = 1.90$ is 21.8, and hence this was the setting of the photometer wedge when measuring star A. For the faint star Q on the same night where the derived magnitude is 14.46, we get that $14.46 - 10.27 = 4.19 = \Delta M$. According to Table III, the mean wedge corresponding to $\Delta M = 4.19$ is 43.7, which is therefore the wedge setting on star Q.

If a shade glass had been used for the readings of the bright stars, as in the series for S Cassiopeiae on 1902, September 6, the procedure is little different. For this night Mo is 11.08 and using this value, the wedge settings on the faint stars Q, R, S, etc., can be found as for the star U Cassiopeiae. For the bright star A, $11.62 - 11.08 = 0.54$. To this amount must be added the correction for the shade glasses used which for this night amounts to 1.74. $1.74 + 0.54 = 2.28$, and according to Table III the setting of the wedge on star A must have been 25.8.

TABLE IV.

YERKES MEASUREMENTS.

	U Cassiopeiae				*S Piscium*			
	1905 Sept. 23	1905 Oct. 6	1905 Oct. 7	Mean Magn.	1905 Nov. 18	1905 Dec. 30	1906 Jan. 16	Mean Magn.
Mo	10.27	10.11	10.50		11.30	10.63	11.02	
A	12.17	.21	.17	12.18	11.42	.21	.36	11.33
B	11.64	.66	.54	11.61	11.65	.77	.65	11.69
C	12.18	.18	.23	12.20	11.84	.72	.73	11.76
D	12.28	.08	.19	12.20	11.88	.84	.85	11.86
E	12.02	.18	.17	12.12	12.24	.47	.41	12.37
Q	14.46	.30	.37	14.38	14.57	.67	.14	14.46
R	14.77	.94	.93	14.88	14.71	.65	.78	14.71
S	15.00	.10	*.93*	15.01	14.87	.67	.63	14.72
T	14.82	*.15*	*.00*	14.99	15.07	.32	.38	15 26
U	14.82	*.00*	*.13*	14.98	15.79	.68	.63	15.70

YERKES MEASUREMENTS.

	S Cassiopeiae						*U Arietis*						
	1902 Feb. 6	1902 Aug. 8	1905 July 23	1905 Sept. 23	1905 Sept. 24	Mean Magn.	1905 Aug. 6	1905 Oct. 6	1905 Oct. 7	1905 Oct. 24	1905 Dec. 30	1906 Jan. 16	Mean Magn.
Shade	1.74				0.86								
Mo	11.08	10.33	9.89	10.48	11.69		11.35	10.75	10.99	11.13	11.12	11.88	
A	11.62	.29	.39	.31	.48	11.42	12.58	.73	.66	.90	.37	.80	12.67
B	11.63	.55	.50	.84	.78	11.66	13.20	.05	.01	.09	.18	.02	13.09
C	11.71	.82	.90	.70	.81	11.79	13.33	*.94*	.12	.27	.34	.19	13.20
D	11.73	.96	.92	*.03*	.74	11.88	12.85	*.18*	*.16*	.91	*.11*	.98	13.03
E	12.19	.24	.17	*.97*	.06	12.13	13.19	.29	.23	*.99*	.15	.18	13.17
Q	15.49	*.55*	.05	*.85*	*.76*	14.94	14.75	.88	.40	*.12*	.44	.68	14.71
R	15.48	*.87*	.15	*.84*	*.90*	15.05	15.16	.63	.02	.31	.07	.28	15.24
S	15.34	*.88*	.22	*.89*	*.93*	15.05	15.32	.75	.36	.78	.36	.45	15.50
T	15.59	*.88*	.10	.18	.14	15.18	14.79	*.00*	.69	*.16*	.53	.78	14.82
U	15.58	.16	.33	.18	.04	15.26	15.26	.41	.13	.70	.08	.14	15.29

	R Persei				*V Tauri*				*V Aurigae*			
	1905 Sept. 23	1905 Oct. 3	1905 Oct. 7	Mean Magn.	1903 Jan. 16	1905 Oct. 8	1905 Oct. 31	Mean Magn.	1904 Feb. 18	1904 March 22	1905 Feb. 25	Mean Magn.
Mo	11.03	10.15	11.13		10.67	11.11	10.07		9.15	10.27	10.35	
A	11.17	.24	.20	11.20	12.39	.33	.54	12.42	11.86	.80	.91	11.86
B	11.70	.75	.71	11.72	12.65	.69	.63	12.66	12.42	.45	.47	12.45
C	11.68	.67	.57	11.64	12.52	.39	.35	12.42	12.40	.34	.31	12.35
D	11.79	.76	.71	11.75	12.22	.21	.36	12.26	12.19	.25	.29	12.25
E	11 72	.65	.87	11.75	12.44	.61	.36	12.47	12.60	.63	.49	12.57
Q	14.32	.42	.59	14.44	14.69	.84	.81	14.78	14.10	*.97*	*.75*	13 94
R	14 31	.41	.64	14.45	14.58	.57	.43	14.53	14.43	.17	.05	14.22
S	15.04	*.98*	.31	15.11	14.34	.31	.28	14.31	14.55	.68	.59	14 61
T	15 19	.49	.30	15.33	14.97	*.11*	*.27*	15.12	14.60	.45	.21	14.42
U	15 40	.35	.70	15.48	15.27	.21	.03	15.17	14.62	.74	.65	14 67

	R Geminorum				*V Cancri*				*R Leonis Minoris*			
	1903 Jan. 16	1904 Feb. 18	1905 Feb. 25	Mean Magn.	1904 March 22	1905 Feb. 25	1905 Oct. 8	Mean Magn.	1903 Dec. 27	1904 Feb. 18	1915 Apr. 3	Mean Magn.
Mo	10.33	9.60	10.13		10.15	10.31	10.27		11.16	10.95	9.98	
A	11 88	.86	.78	11.84	11.51	.40	.62	11.51	12.19	.31	.57	12 36
B	11 93	.74	.57	11.75	11.67	.93	.70	11.77	13.10	*.80*	*.65*	12 85
C	12 11	.05	.38	12.18	11.97	*.11*	*.18*	12.09	12.89	*.02*	.99	12 97
D	11 87	*.15*	*.07*	12.03	12.58	.64	.40	12.54	12.82	85	88	12 85
E	12 45	.62	.45	[12.51]*	12.51	.19	.37	12.36	13.28	.30	.16	13 25
Q	14 63	.76	.59	14.66	14.12	.07	.31	14.17	14.40	.00	.46	14 29
R	14 83	.90	.64	14.79†	14.69	.67	.92	14.76	14.70	.65	.75	14 70
S	14 98	*.01*	.87	14.95	14.45	.36	.63	14.48	15.29	.07	.22	15 19
T	14.92	*.05*	.97	14.98	15.34	.63	.64	15.54	15.12	.00	.04	15 05
U	14 63	.85	.59	14.69	15.52	.53	.57	15.54	15.35	.34	.36	15 35

* Star E is the variable Z Geminorum. Not used as standard.

† Not the same faint stars as measured at Lick.

YERKES MEASUREMENTS.

	W Leonis					*T Ursae Majoris*				*U Virginis*			
	1903 May 23	1903 Dec. 27	1904 Feb. 21	1905 Feb. 25	Mean Magn.	1903 June 20	1903 June 27	1905 April 1	Mean Magn.	1903 May 23	1904 Feb. 18	1904 Feb. 21	Mean Magn.
Mo	10.12	10.66	10.41	10.50		10.84	11.56	10.56		10.26	10.55	10.17	
A	12.32	.53	.51	.38	12.44	12.61	.42	.76	12.60	11.31	—	.37	11.34
B	12.49	.40	.46	.35	12.42	12.99	.82	.77	12.86	11.33	.92	.77	11.67
C	12.51	.63	.43	.60	12.54	13.06	.23	*.98*	13.09	12.49	.04	.26	12.26
D	12.64	.60	.62	.71	12.64	12.84	.87	*.01*	12.91	12.64	.51	.51	12.55
E	12.95	.79	.90	.88	12.88	13.49	.68	.46	13.54	12.66	.74	.53	12.64
Q	15.06	.30	.62	.28	15.32	15.14	.26	.06	15.15	14.51	.49	.44	14.48
R	14.85	*.30*	*.27*	.18	15.15	14.83	.90	.92	14.88	15.21	.17	.14	15.17
S	15.32	.53	.57	.45	15.47	14.74	.80	*.02*	14.85	14.78	.90	*.14*	14.94
T	15.45	.97	.91	.90	15.81	15.68	.57	.71	15.65	15.40	.14	.53	15.36
U	15.09	.35	.56	.19	15.30	16.25	.02	*.97*	16.08	15.49	.45	.58	15.51

	S Bootis				*R Camelopardalis*				*R Serpentis*			
	1902 Sept. 26	1903 Jan. 9	1903 June 27	Mean Magn.	1915 Apr. 17	1915 May 1	1915 May 13	Mean Magn.	1905 June 20	1905 June 30	1905 July 25	Mean Magn.
Mo	10.03	11.08	11.70		10.39	10.66	10.14		10.93	10.07	11.12	
A	12.31	*.95*	.12	12.13	11.75	.87	.85	11.82	11.51	.49	.40	11.47
B	12.49	.35	.47	12.44	12.40	.03	*.98*	12.14	11.46	.47	.52	11.48
C	12.76	*.05*	.66	12.82	12.13	.37	.20	12.23	11.48	.49	.49	11.49
D	12.84	.88	.98	12.90	12.41	.48	.49	12.46	11.93	*.01*	.92	11.95
E	12.63	.77	.80	12.73	12.61	.57	.78	12.65	12.33	.24	.35	12.31
Q	14.88	*.04*	.90	14.94	14.75	.56	.89	14.73	13.88	.68	.76	13.77
R	14.82	.93	.68	14.81	15.06	*.78*	*.85*	14.90	14.21	.28	.43	14.31
S	15.05	.20	*.75*	15.00	15.56	.51	.38	15.48	14.67	.68	.84	14.73
T	15.35	.63	.55	15.51	15.67	.82	.47	15.65	15.02	.27	.16	15.15
U	15.44	.72	.69	15.62	15.78	.93	.54	15.75	15.47	.50	.45	15.47

	W Herculis					*R Draconis* ⊕					
	1902 Aug. 1	1902 Aug. 8	1903 July 18	1904 April 18	Mean Magn.	1916 May 4	1916 May 4	1916 June 26	1916 June 26	1916 June 26	Mean Magn.
Mo	10.58	10.85	10.65	10.17		10.74	10.95	11.13	10.77	10.82	
A	11.48	.42	.33	.37	11.40	11.33	.20	.35	.33	.29	11.30
B	11.58	.87	.63	.60	11.67	11.82	.82	.58	.70	.71	11.73
C	11.10	.29	.17	.53	11.27	12.45	.33	.32	.31	.32	12.35
D	11.96	.80	*.06*	.80	11.90	12.36	.35	.59	.47	.46	12.45
E	12.48	.26	.45	.34	12.38	12.23	.49	.35	.39	.42	12.38
Q	14.88	.70	.65	.54	14.69	14.86	*.06*	*.36*	*.21*	.95	15.09
R	15.17	.02	.05	.32	15.14	15.57	.49	.57	.40	.27	15.46
S	15.71	.62	.45	.61	15.60	15.60	.41	.58	.41	.19	15.44
T	15.99	.36	.61	.53	15.62	15.20	.09	.12	*.67*	*.83*	14.98
U	16.03	*.89*	*.66*	*.67*	15.81	15.00	*.86*	*.99*	*.81*	*.88*	14.91

⊕ Not the same faint stars as measured at Lick.

YERKES MEASUREMENTS.

	S Herculis							*R Aquilae*			
	1900 May 30	1900 June 1	1900 June 8	1905 July 4	1905 July 25	1905 July 30	Mean Magn.	1903 July 18	1905 July 4	1905 July 25	Mean Magn.
Shade										0.86	
Mo	10.20	10.13	10.47	10.86	11.46	10.25		10.93	10.81	11.99	
A	11.56	.37	*.96*	.62	.41	.35	11.38	11.33	.29	.37	11.33
B	11.25	.59	.75	.31	.67	.57	11.52	11.85	.71	.72	11.76
C	11.61	.44	.35	30	.38	.30	11.40	11.85	88	*.06*	11.93
D	11.54	.67	.79	.86	.77	.98	11.77	11.79	.88	*.00*	11.89
E	12.03	*.94*	.13	*.90*	*.76*	*.80*	11.93	12.10	.12	*.75*	11.99
Q	14.81	.73	*.03*	.80	*.25*	*.16*	14.96	14.96	*.06*	.90	14.97
R	14.97	.97	*.17*	*.08*	*.54*	*.25*	15.16	15.02	.01	.14	15.06
S	15.23	.19	.45	.31	.73	.59	15.42	15.33	.51	.56	15.47
T	15.13	.13	.12	.05	.51	.56	15.25⊕	15.71	.81	.56	15.69
U	14.48	.56	.58	.44	.94	.70	14.62⊕	15.43	.53	.55	15.50

	χ Cygni					*R Vulpeculae*				
	1904 April 18	1905 July 30	1905 Aug. 1	1905 Aug. 19	Mean Magn.	1905 Aug. 6	1905 Aug. 22	1905 Sept. 19	1905 Sept. 24	Mean Magn.
Shade						0.86				
Mo	10.24	10 06	9.98	9.91		10.83	10.59	10.54	10.49	
A	10.68	.47	.49	.60	10.56	10.63	.56	.57	.53	10.57
B	11.18	*.94*	.03	.13	11.07	10 57	.22	.46	.47	10 43
C	11 05	.25	.03	.12	11.11	10.54	.56	.51	.57	10 54
D	11.38	.39	.39	.47	11 41	10.65	.99	.74	.89	10.82
E	11.25	.49	.61	.22	11.39	11 08	.12	.18	*.99*	11.09
Q	13.81	.87	.83	.79	13.82	14.14	.62	.44	.35	14 39
R	13.82	*.11*	.93	.82	13.92	14.37	.56	.58	.59	14 52
S	14.80	.80	.78	.72	14.78	14.84	*.00*	*.27*	*.09*	15 05
T	14.63	.56	.54	.60	14.58	14.99	*.16*	*.15*	*.46*	15 19
U	15 19	.40	.13	.21	15 23	14.61	.66	.79	.68	14 68

	R Lacertae					*R Pegasi*			
	1905 Aug. 22	1905 Sept. 4	1905 Sept. 19	1905 Sept. 23	Mean Magn.	1905 Sept. 4	1905 Sept. 19	1905 Oct. 31	Mean Magn.
Mo	11.00	11 30	10 85	10.46		10.73	10.64	10.70	
A	11.76	.88	.81	.98	11.86	11.83	.75	.64	11 74
B	12 44	.40	.46	.34	12.41	11.85	*.05*	*.01*	11.97
C	12.43	.15	.41	.41	12.35	12.12	*.94*	.12	12 06
D	12 30	.53	.24	.37	12.36	11.84	.74	.72	11.77
E	12 48	.43	.46	.32	12.42	12.03	.18	.19	12 13
Q	14 20	.19	.12	.48	14.25	14.58	.73	73	14 68
R	14 19	.54	.14	.48	14.34	14.88	*.19*	96	15 01
S	14 81	*.20*	80	*.11*	14.98	15.61	.58	.38	15.52
T	14 79	.99	.52	*.10*	14.85	14.96	*.09*	*.01*	15.02
U	15 65	.85	.97	.85	15.83	15.09	.44	.44	15 32

⊕ Not the same faint stars as measured at Lick.

Measures at the Lick Observatory.

Standards of the sixteenth magnitude were measured on all of the thirty-six Rumford regions. Professor Robert G. Aitken made most of the measures, though measures on a number of nights were made by Heber D. Curtis, by Joel Stebbins, and by S. D. Townley. As already stated, Aitken measured the stars of sixteenth magnitude chosen by Parkhurst in the regions north of the equator except in the field of R Draconis. The faint stars in the twelve regions south of the equator were selected by Aitken. No attempt was made to select stars near or at the actual limit of vision, for it was recognized that such stars would be difficult to measure on any but the very best nights. On the majority of nights it was possible to see stars a full magnitude fainter than the faintest standards selected.

The actual measurement was not begun until June, 1902, and it was continued until completion in January, 1904.

It was promptly discovered that it was essential to good work to have sharply defined star images. If the images are very large, or at all blurred, no accordant comparisons with the artificial star are possible. Care was therefore taken to use nights of fairly good seeing and of course, to avoid moonlight nights, nights when any haze or clouds could be detected, or the time near twilight or dawn.

The actual observations were carried out in the following manner: four consecutive photometric settings were made on each star, the assistant reading the wedge scale and making the record. If he found the settings were not sufficiently accordant, he asked that a fifth, and rarely a sixth setting be made, the observer remaining ignorant of the readings obtained. The five faint stars F, and the five twelfth magnitude standards, S, were measured alternately in the order, F, S, F, S, F. A complete set of measures thus required at least 100 wedge settings, and the plan contemplated a complete set on each of three nights for each field. The time required for one complete set varied from about an hour to an hour and a half. Great care was taken to guard against any irregular variation in the brightness of the artificial star, the current for the lamp being taken from a battery of five storage cells which was not drawn upon for any other purpose. In a few instances sudden changes were suspected, and the measures were at once rejected and the set repeated. The effects of slight progressive changes in the brightness of the artificial star are eliminated by the method used in making the measures.

Settings near both ends of the wedge were avoided. This was possible because two neutral tinted shade glasses were provided, one or both of which could be inserted in the cone of rays for the true star. There was also a shade glass that could be inserted to reduce the light of the artificial star. This was rarely used, but the other two shade glasses

were commonly employed for the twelfth magnitude standards. The average scale readings for the faintest stars are about forty on the wedge, and for the brightest stars, greater than fifteen.

An attempt was made to keep the light forming the artificial star as constant as possible from night to night. However, when every care was taken, the artificial star could not be made quite of the same color as the average real stars, and undoubtedly these differed among themselves. Moreover, the artificial star image could not be varied in sharpness to meet variations in seeing taking place during a set of measures. In the work at Lick, the real star was always compared with the image of the artificial star reflected by the front side of the plane glass reflector, and the two images to be compared were always placed in the same relative positions, and so that the line joining them was parallel to the horizon.

The calibration of wedge III used at the Lick Observatory was carried out by Maddrill, and a description is given in *Astrophysical Journal*, 22, 138, 1905. A Lummer-Brodhun photometer was employed. This photometer compares surfaces and not point sources, and consequently it was not surprising that the laboratory value of the calibration curve was found not to be sufficiently extended so that a "stretching factor" became necessary. For the purpose of determining this "stretching factor" a series of measures was made by Aitken on stars of the Pleiades selected from the list determined by Müller and Kempf. Fifty-one pairs of stars were observed, the average range of the pair being 1.9 magnitudes. The 12-inch refractor was employed, part of the time with full aperture and part of the time with six-inch and three-inch apertures. The shade glasses were used in some of the measures, the values of their absorption being taken from the laboratory determination. Part of the tabulated results (*loc. cit.* p. 147) are here reproduced.

Aperture	Shades	Stretching Factor	
12 in.	None	+0.246	±0.015
6 in.	None	+0.263	±0.020
6 in.	Both	+0.291	±0.031
3 in.	None	+0.328	±0.049

Comparing the three values in the table when no shade glasses were used it is readily seen that the stretching factor necessary to obtain Müller and Kempf's magnitudes from the photometric settings at the telescope become greater and greater as the aperture employed is reduced. Since the difference in magnitude of the bright and faint stars

was approximately the same, 1.9 magnitudes for each of the three apertures employed, it is apparent that the eye of the observer saw less contrast, and consequently he measured fewer divisions of the photometric scale with the small aperture of three inches than with the larger apertures of six and twelve inches. Apparently, therefore, an increase in aperture makes the faint stars more clearly visible, but the eye of the observer does not estimate that the brighter stars are proportionally increased. What, therefore, should be the stretching factor to be employed for an aperture of thirty-six inches? In spite of the decrease of stretching factor revealed by the table for increase of aperture, the Lick observers thought best to combine the four determinations above into one. Accordingly the tabulated values were weighted in inverse ratio to the squares of their probable errors and combined, producing the stretching factor 0.261 ± 0.011. The ordinates of the laboratory curve were therefore increased 0.261 of their own length. The resulting calibration curve is given in tabular form (*loc. cit.* p. 147) and need not be repeated here. The measures were reduced by means of it.

On account of the method employed in securing the stretching factor one cannot have any great confidence in the correctness of the scale of the Lick magnitudes. It is quite possible that too great a stretching factor was employed and that in consequence there is too great difference in magnitude between the standard stars of twelfth magnitude and the faint stars of sixteenth magnitude.

Unfortunately the wedge was destroyed by moisture during the winter of 1916 and it is therefore impossible to repeat the calibration.

In Table V are given the results of the measurements with the Lick refractor, the arrangement being similar to that of Table IV of Yerkes measures. The names of the observers are A = Aitken, C = Curtis, S = Stebbins, and T = Townley.

TABLE V.

Lick Measurements.

	S Ceti				*U Cassiopeiae*				*S Piscium*		
	1902 Sept. 5	1902 Sept. 26	1902 Sept. 27	Mean Magn.	1902 Oct. 31	1903 Jan. 16	1903 Jan. 17	Mean Magn.	1903 Sept. 25	1903 Oct. 15	Mean Magn.
Obs.	*A*	*A*	*A*		*C*	*A*	*A*		*A*	*A*	
Seeing	*f*	*f*	*f*						*g*	*g*	
Shade	0.89	0.89	0.89		0.89	1.75	1.75		1.75	0.89	
Mo	11.43	11.24	11.17		11.05	12.08	12.19		11.73	11.01	
A	12.36	.42	.26	12.35	12.18	.31	.27	12.25	11.41	.27	11.34
B	12.51	.33	.56	12.47	11.59	.56	.72	11.62	11.50	.62	11.56
C	12.58	.62	.69	12.63	12.16	.17	.15	12.16	11.81	.75	11.78
D	12.74	.76	.72	12.74	12.18	*.98*	.04	12.07	11.80	.88	11.84
E	12.83	.89	.81	12.84	12.21	.31	.14	12.22	*a*	*a*	*a*
Q	14.68	*.15*	*.04*	14.96	14.62	.84	.79	14.75	14.90	.58	14.74
R	15.18	.55	.24	15.32	15.12	.10	.25	15.16	15.11	*.83*	14.97
S	15.59	.64	.42	15.55	15.12	.36	.26	15.25	15.32	.05	15.18
T	15.60	.62	.49	15.57	15.09	.32	.32	15.24	15.69	.28	15.48
U	15.68	.73	.56	15.66	14.99	*.83*	*.19*	15.17	16.08	*.47*	15.78

	S Cassiopeiae				*R Ceti*				*U Arietis*			
	1902 Oct. 5	1903 Jan. 29	1903 Jan. 30	Mean Magn.	1902 Sept. 27	1902 Oct. 5	1902 Oct. 31	Mean Magn.	1903 Aug. 21	1903* Aug. 27	1903 Sept. 24	Mean Magn.
Obs.	*C*	*C*	*A*		*A*	*A*	*A*		*A*	*A*	*A*	
Seeing					*f*	*p*	*rp*		*f*	*p*	*f*	
Shade	1.75	1.75	1.75		0.89	1.75	0.89		1.75	1.75	1.75	
Mo	11.47	11.62	13.04		11.54	11 89	12.10		12.37	11.92	11.47	
A	11.56	.20	.64	11.47	12.25	.16	.09	12.17	12.64	.56	.27	12.49
B	11.43	.78	.68	11.63	12.43	.38	.49	12.43	12.91	*.12*	*.12*	13.05
C	11.68	.60	.62	11.63	12.44	.36	.41	12.40	13.19	.05	.08	13.11
D	11 81	97	.65	11.81	12.74	.87	.74	12.78	13.23	.11	.20	13.18
E	12 36	.29	.28	12.31	12.76	.83	.90	12.83	13.20	.32	.50	13.34
Q	15 09	*61*	.06	14.92	15.78	.64	.79	15 74	14.86	*.06*	*.06*	14.99
R	15 10	*.85*	.18	15 04	15.61	91	*.13*	15.88	15 29	.44	.44	15 39
S	15 14	*.90*	.39	15.14	15.74	.80	*.15*	15 90	15 26	.71	.62	15 53
T	15 45	.21	.51	15 39	15.83	*.18*	*.27*	16 09	14 95	*.14*	*.24*	15 11
U	15 51	72	.54	15 59	15.94	*.09*	*.44*	16 16	15.11	.43	.35	15 30

a Hagen 24 measured by mistake.

* Two sets of measures on faint, and one set on bright stars.

Lick Measurements.

	R Persei				*V Tauri*				*S Orionis*			
	1902 Oct. 31	1903 Jan. 29	1903 Aug. 27	Mean Magn.	1903 Aug. 27	1903 Sept. 24	1903 Sept. 25	Mean Magn.	1902 Oct. 31	1903 Jan. 29	1903 Oct. 16	
Obs.	*C*	*A*	*A*		*A*	*A*	*A*		*A*	*C*	*A*	
Seeing	*p*	*p*	*p*		*p*	*f*	*g*		*vp*	*p*	*g*	
Shade	1.75	1.75	1.75		1.75	1.75	1.75		0.89	1.75	0.89	
Mo	11.45	11.94	11.43		11.63	11.78	12.14		11.39	11.85	11.80	
A	11.04	.28	.19	11.17	——	——	——	*d*	11.75	.81	.71	11.76
B	11.67	.69	.63	11.66	——	——	——	*c*	11.60	.65	.72	11.66
C	11.72	.67	.73	11.71	12.38	.36	.45	12.40	11.62	.67	.62	11.64
D	11.97	.69	.82	11.83	12.41	.38	.34	12.38	12.13	*.99*	.06	12.06
E	11.65	.70	.66	11.67	12.48	.55	.50	12.51	12.04	.02	.02	12.03
Q	14.87	.97	*.12*	14.99	15.23	.59	.16	15.33	14.59	.49	.39	14.49
R	14.62	.72	.86	14.73	14.78	*.00*	.79	14.86	14.99	*.23*	*.58*	15.27
S	15.28	.47	.36	15.37	14.89	.96	.56	14.80	15.33	.33	.33	15.33
T	15.69	.76	.66	15.70	15.43	.36	.20	15.33	15.52	.29	.38	15.40
U	15.52	.67	.70	15.63	15.43	.79	.37	15.53	15.55	.21	.54	15.43

	V Aurigae				*R Geminorum*				*U Puppis*			
	1903 Oct. 17	1903 Oct. 22	1903 Oct. 24	Mean Magn.	1903 Oct. 17	1903 Oct. 22	1903 Oct. 24	Mean Magn.	1903 Dec. 19	1903 Dec. 20	1904 Jan. 9	Mean Magn.
Obs.	*A*	*A*	*A*		*A*	*A*	*A*		*A*	*A*	*A*	
Seeing	*g*	*g*	*g*		*g*	*g*	*g*		*p*	*p*	*f*	
Shade	1.75	1.75	1.75		1.75	1.75	1.75		1.75	1.75	1.75	
Mo	12.04	11.93	12.27		12.33	11.72	11.98		12.09	11.93	12.59	
A	11.74	.72	.78	11.75	11.74	.82	.87	11.81	11.53	.47	.44	11.48
B	12.34	.39	.42	12.38	11.73	.62	.64	11.65	12.01	*.98*	.06	[12.02]*f*
C	12.53	.48	.48	12.50	12.19	.27	.09	12.18	11.71	.54	.70	11.65
D	12.38	.42	.28	12.36	12.14	.07	.18	12.12	11.33	.38	.32	11.34
E	12.51	.48	.51	12.50	12.49	.44	.41	[12.45]*e*	11.11	.29	.23	11.21
Q	14.45	.59	.61	14.55	15.14	.25	.39	15.26	15.08	*.85*	*.98*	14.97
R	14.52	.89	.91	14.77	——	——	——	——	15.17	*.75*	.22	15.04
S	14.94	*.50*	*.51*	15.32	15.55	.69	.69	15.64	14.96	*.05*	*.33*	15.11
T	14.79	*.21*	*.12*	15.04	15.84	.85	.71	15.80	15.66	.27	.52	15.48
U	15.13	.35	.48	15.32	15.42	.08	.31	15.27	15.73	.52	.69	15.65
R′					14.22	*.75*	.10	14.02*b*				

b Not the same faint stars as measured at Yerkes.
c Not measured because star is double.
d Hagen 4 measured.
e Star E is the variable Z Geminorum. Not used as standard.
f Hagen 82 measured by Professor Pickering. Not used as standard.

LICK MEASUREMENTS.

	V Cancri				*T Hydrae*				*R Leonis Minoris*			
	1903 Dec. 25	1903 Dec. 26	1904 Jan. 9	Mean Magn.	1903 Dec. 19	1903 Dec. 20	1903 Dec. 25	Mean Magn.	1903 April 27	1903 May 14	1903 Dec. 26	Mean Magn.
Obs.	*A*	*A*	*A*		*A*	*A*	*A*		*A*	*A*	*A*	
Seeing	*f*	*g*	*f*		*p*	*p*	*f*		*f*	*f*	*g*	
Shade	1.75	1.75	1.75		1.75	1.75	1.75		0.89	1.75	1.75	
Mo	12.29	12.89	12.83		12.49	12 35	12.48		12.43	11.74	13.02	
A	11.70	.59	.71	11.67	11.50	.82	.65	11.66	12.30	.32	.46	12.36
B	11.80	.88	.77	11.82	12.06	*.86*	*.90*	11.94	12.66	.72	.89	12.76
C	12.01	.13	*.89*	12.01	12.18	.06	.05	12.10	13.09	.00	*.90*	13.00
D	12.35	.21	.46	12.34	12.18	.07	.12	12.12	12.98	.86	.75	12.86
E	12 41	.46	.43	12.43	11.99	*.11*	*.18*	12.09	13.26	.35	.26	13.29
Q	14.42	.52	.80	14.57	15.19	.11	*.90*	15.07	14.27	.69	.45	14.47
R	14.90	.99	*.04*	14 98	15.35	.04	*.89*	15.09	14.40	.70	.76	14.62
S	14 65	.78	*.01*	14.81	15.58	.44	.30	15.44	15.03	.56	.01	15.20
T	15.35	.60	.79	15.58	15.38	.54	.43	15.45	14.87	*.35*	.99	15.07
U	15.54	.68	.82	15.68	16.09	.04	*.88*	16.00	15.23	.84	.20	15.42

	W Leonis				*T Virginis*				*T Ursae Majoris*			
	1903 Dec. 20	1903 Dec. 25	1903 Dec. 26	Mean Magn.	1903 Feb. 28	1903 April 26	1903 April 27	Mean Magn.	1903 April 30	1903 May 23	1903 May 29	Mean Magn.
Obs.	*A*	*A*	*A*		*C*	*C*	*C*		*A*	*C*	*A*	
Seeing	*p*	*f*	*g*		*p*	*g*	*f*		*g*	*f*	*g*	
Shade	1.75	1.75	1.75		0 89	0.89	0.89		0.89	1.75	1.75	
Mo	12.51	12.69	12.76		11.19	11 20	11.29		12.31	12 77	12.77	
A	12.38	.49	.53	12.47	11.68	.91	.65	11.75	12.58	.44	.61	12.54
B	12.32	.25	31	12.29	11.56	.50	.64	11.57	12.60	.64	.70	12.65
C	12 64	.57	47	12.56	12 04	*.99*	*.91*	11.98	13.30	.25	.28	13.28
D	12 82	72	.69	12 74	12.41	.20	.33	12.31	13.32	.46	.21	13.33
E	12 79	.88	.92	12 86	12.07	.17	.23	12.16	13.21	.19	19	13.20
Q	15.80	.54	34	15 56	15.30	.14	.34	15 26	15.56	.29	.49	15 45
R	15 55	.44	31	15 43	15.54	32	57	15 48	15 10	*93*	04	15 02
S	15 65	76	47	15 63	15.45	54	.66	15.55	14 90	.96	92	14 93
T	16 15	26	*96*	16 12	15.56	61	.76	15 64	16 02	*66*	*87*	15 85
U	15 49	27	.19	15 32	15.55	65	.74	15.65	16 20	26	.37	16 28

Lick Measurements.

	U Virginis				*S Virginis*				*S Bootis*			
	1903 May 23	1903 May 29	1903 June 24	Mean Magn.	1902 June 6	1903 Feb. 28	1903 April 26	Mean Magn.	1903 June 23	1903 July 23	1903 July 24	Mean Magn.
Obs.	*A*	*A*	*A*		*T*	*A*	*A*		*A*	*A*	*A*	
Seeing	*f*	*g*	*p*		*f*	*f*	*g*		*f*	*f*	*g*	
Shade	0.89	0.89	1.75		0.89	0.89	0.89		1.75	1.75	1.75	
Mo	11.06	11.47	11.93		11.70	11.93	12.01		12 85	12.83	13.44	
A	11.44	.34	.50	11.43	12.38	.23	.04	12.22	12.18	.42	.20	12.27
B	11.71	.27	.44	11.47	12.19	.02	.19	12.13	12.40	.48	.66	12 51
C	12.01	.34	*.97*	12.11	12.41	.33	.39	12.38	12.74	.70	.65	12.70
D	12.54	.63	.62	12.60	12.76	.67	.71	12.71	12.82	.66	.76	12.75
E	12.75	.87	.88	12.83	12 48	.97	.89	12.78	12.86	.77	.76	12.80
Q	14.67	.98	*.19*	14.95	14.95	*.41*	*.56*	15.31	14.96	.81	.88	14.88
R	15 19	.74	.66	15.53	15.26	.62	.70	15 53	14.74	.52	.70	14.65
S	14.73	.97	*.18*	14.96	15.53	.94	*.02*	15.83	15.15	.00	*.71*	14.95
T	15 35	.70	.95	15.67	15.82	*.09*	*.14*	16 02	15 31	.41	.19	15.30
U	15.55	96	*.18*	15.90	15.89	*.33*	*.28*	16.17	15.55	.63	.32	15.50

	R Camelopardalis				*R Serpentis*				*RR Librae*			
	1903* July 17	1903 July 23	1903 July 24	Mean Magn.	1902 July 5	1903 April 30	1903 June 2	Mean Magn.	1902 June 4	1902 June 6	1902 June 7	Mean Magn.
Obs.	*A*	*A*	*A*		*T*	*C*	*A*		*T*	*A*	*T*	
Seeing	*g*	*f*	*g*		*f*	*g*	*p*		*f*	*f*	*g*	
Shade	0.89	1.75	1.75		0.89	1.75	1.75		0.89	0.89	0.89	
Mo	12.10	12.68	12.22		12.28	11.68	11.26		11.31	11.97	11.29	
A	11.86	.65	.57	11.69	11.43	.39	.29	11.37	11.69	.58	.60	11.62
B	12.33	.25	.15	12.24	11.47	.37	.50	11.45	11.73	.62	.67	11.67
C	12.17	.39	.49	12.35	11.52	.48	.58	11.53	11.36	.83	.66	11.62
D	12.53	.56	.68	12.59	12.08	.01	*.99*	12 03	11.49	.49	.35	11.44
E				——	12.21	.42	.33	12.32	11.80	.53	.76	11.70
Q	14.56	.58	.75	14.63	13.96	*.31*	.87	14.05	14.14	.15	*.84*	14.04
R	14.86	.99	*.00*	14.95	14.43	.90	.86	14.73	14 37	.42	.22	14.34
S	15.53	.54	.54	15.54	14.75	*.03*	*.20*	14 99	14.63	.48	.39	14.50
T	15.66	.77	.80	15.74	15.03	.67	.27	15.32	14.96	*.22*	.87	15.02
U	15.87	.98	.81	15.89	15.35	.69	.55	15.53	15.32	.54	.16	15 34

* Two sets of measures only on faint, and one set on bright stars.

Lick Measurements.

	R and S Scorpii				*W Herculis*				*R Draconis b*			
	1902 June 10	1902 July 4	1902 July 5	Mean Magn.	1903 June 23	1903 June 26	1903 June 30	Mean Magn.	1903 Aug. 19	1903 Aug. 20	1903 Aug. 21	Mean Magn.
Obs.	*A*	*T*	*T*		*S*	*A*	*A*		*A*	*A*	*A*	
Seeing	*p*	*p*	*f*		*f*	*g*	*f*		*p*	*f*	*f*	
Shade	0.89	0.89	0.89		1.75	1.75	1.75		1.75	1.75	1.75	
Mo	12.27	12 05	11.94		11 32	11.93	12.45		12.65	12.21	12.86	
A	11.61	.52	.85	11.66	11.51	.55	.40	11.49	11.51	.53	.45	11.50
B	12.01	*.86*	.00	11.96	11.68	.70	.66	11.68	11.83	.77	.87	11.82
C	12.00	.17	.11	12 09	11.38	.58	.41	11.46	12 06	.29	.17	12.17
D	12.30	.41	.06	12.26	11.79	.82	*.00*	11.87	12.54	.29	.31	12.38
E	12.59	.55	.51	12.55	12.26	*.97*	.17	12.13	12.26	.32	.40	12.33
Q	15.05	*.87*	*.58*	14.83	15.48	.38	.45	15.43	16.32	.55	.41	16.43
R	15 29	.18	*.79*	15.09	16 08	*.82*	*.80*	15 88	16 48	.78	.45	16.57
S	15.66	.57	.18	15.47	16 56	.19	.48	16 38	16 75	.67	.67	16.70
T	15 69	.64	.22	15.52	16 57	.05	.35	16 27	16.83	.77	.68	16.76
U	16 15	*.73*	*.39*	15.76	16 83	.48	.65	16 62	17.08	*.78*	.01	16.96

	S Herculis				*R Aquilae*				*Z Sagittarii*			
	1903 ⊕ June 25	1903 ⊕ June 26	1903 June 27	Mean Magn.	1903 May 21	1903 May 31	1903 June 24	Mean Magn.	1902 July 4	1902 Aug. 30	1902 Oct. 3	Mean Magn.
Obs.	*S*	*S*	*A*		*C*	*A*	*A*		*T*	*A*	*A*	
Seeing	*g*	*g*	*f*		*f*	*f*	*p*		*p*	*vp*	*p*	
Shade	1.75	1.75	1.75		1.75	1.75	1.75		0 89	1.75	0 89	
Mo	11.71	11.85	11.82		12.43	12.73	12.53		11.66	10.98	10 60	
A	11.34	.24	.39	11.32	11.46	.56	.61	11.54	10.—	.75	.43	10.59
B	11.47	.51	.51	11.50	11.61	.72	.67	11.67	10.84	*.02*	.93	10.93
C	11 51	49	.56	11.52	11.85	.63	.65	11.71	11.09	*.99*	*.95*	11.01
D	11 97	*.02*	.82	11.94	11.81	.84	.81	11 82	11.46	.29	.62	11.46
E	11.70	.72	.73	11.72	12.21	.27	.08	[12.19]*g*	11.48	.40	.53	11.47
Q	15.61	.72	*.95*	15.31	15.14	.51	.29	15.31	14.19	.58	.39	14.39
R	16.18	.37	*.80*	16 04	15 25	.59	.34	15 39	14.38	.83	.76	14 66
S	15.91	.84	42	15 65	15 67	*.19*	88	15 91	14.27	.94	.81	14.67
T	16.20	.31	07	16 10*b*	15 69	*.26*	86	15 94	14.86	*.57*	.99	15 07
U	16.13	15	*.75*	15 94*b*	15.—	99	*.03*	16 01	15.—	.54	.09	15 32

b Not the same faint stars as measured at Yerkes.
⊕ Measures on faint stars given half weight.
g Hagen 37 by mistake. Not used as standard.

LICK MEASUREMENTS.

	χ Cygni				*R Vulpeculae*				*V Capricorni*			
	1903 May 1	1903 June 25	1903 Aug. 22	Mean Magn.	1902⊕ Nov. 21	1902⊕ Nov. 30	1903 May 1	Mean Magn.	1902 Aug. 30	1902 Sept. 5	1902 Sept. 7	Mean Magn.
Obs.	*C*	*A*	*A*		*A*	*C*	*A*		*A*	*A*	*A*	
Seeing	*f*	*g*	*f*		*vp*	*p*	*f*		*vp*	*g*	*g*	
Shade	1.75	1.75	1.75		1.75	1.75	1.75		0.89	0.89	0.89	
Mo	11.67	11.18	11.60		11.59	10.82	11.86		10.57	10.65	10.79	
A	10.44	.85	.79	10.69	10.41	.61	.73	10.62	10.89	.70	.82	10 80
B	11.11	.10	.06	11.09	10.48	.51	.23	10.36	11.27	.27	.17	11 24
C	11.17	*.98*	.17	11.11	10.75	.62	.70	10.69	11.13	.18	.20	11.17
D	11.41	.17	.06	11.21	11.11	*.99*	.07	11.06	11.22	.34	.26	11.27
E	11.41	.43	.46	11.43	——	——	——	——	11.33	.35	.36	11.35
Q	14.35	.60	.48	14.48	15.27	*.37*	*.61*	14.72	14.31	.44	.42	14.39
R	14.67	.55	.48	14.57	15.33	*.42*	*.75*	14.81	14.66	.49	.41	14.52
S	14.90	*.30*	*.22*	15.14	15.86	*.94*	.53	15.46	14.56	.69	.41	14.55
T	14.82	*.06*	*.10*	14.99	15.60	.20	.46	15 43	14 67	.63	.62	14 64
U	15.23	.50	.33	15.35	15.45	*.97*	*.87*	15 04	14.88	.78	.86	14 84

	R Lacertae				*S Aquarii*				*R Pegasi*			
	1902 Dec. 20	1903 Jan. 16	1903 July 18	Mean Magn.	1902 Aug. 1	1902 Aug. 2	1902 Aug. 29	Mean Magn.	1902 Oct. 3	1903 June 24	1903 June 25	Mean Magn.
Obs.	*A*	*C*	*A*		*A*	*A*	*A*		*C*	*S*	*A*	
Seeing	*f*	*f*	*f*		*f*	*f*	*f*		*p*	*p*	*g*	
Shade	0.89	0 89	1.75		0.89	1.75	0.89		0.89	1.75	1.75	
Mo	11.99	11.37	11.99		11.43	11.67	10.92		11.02	12.65	11.22	
A	11.93	.87	.69	11.83	10.97	*.05*	.07	11.03	11.70	.29	.71	11.57
B	12.06	.38	.35	12.26	11.03	*.94*	.16	11.04	11.89	*.17*	.97	12.01
C	12.13	.42	.33	12.29	12.04	.00	*.94*	11.99	12.14	.05	*.91*	12.03
D	12.64	.36	.59	12.53	11.87	.77	.75	11.80	11.99	.84	.82	11.88
E	12.66	.37	.42	12.48	11.87	*.06*	.86	11.93	11.95	*.33*	*.25*	12.18
Q	14.59	.80	.32	14.57	14.45	.71	.26	14.47	14.90	*.12*	*.00*	15.01
R	14.39	.64	.28	14.44	14.74	.93	.70	14.79	15.20	.29	.34	15.28
S	14.93	*.13*	.72	14.93	15.46	.82	.26	15.51	15.41	.75	.63	15.60
T	14.79	*.08*	.62	14.83	15.75	*.01*	.38	15.71	15.01	.41	.48	15.30
U	15.95	.70	.58	15.74	15.83	*.05*	.44	15.77	15.27	.47	.52	15.42

⊕ Measures on faint stars given half weight.

Measures at the Leander McCormick Observatory.

In accordance with the original plan, the faint standards of the fifteenth magnitude were measured by Heber D. Curtis, then Vanderbilt fellow at the University of Virginia. Four photometric settings were made for each measure, three measures being made on each of the faint stars, F, and two on the standard stars of twelfth magnitude, S, in the order F, S, F, S, F. Each of the regions was measured on at least three nights. All thirty-six of the Rumford regions were observed, the measurements being completed in June, 1902.

As already stated, (page 217), the stars of fourteenth magnitude were also measured at the Leander McCormick Observatory, the work being done by T. McN. Simpson, and F. W. Reed, Vanderbilt fellows. The general method followed was similar to that of Curtis. Simpson and Reed placed the real star to be measured midway between the images of the artificial star reflected from front and back surfaces of the diagonal plate. A compromise focus was necessary. Each observer used his right eye and then his left eye for observing, and the real star was compared with each of the images of the artificial star. Each of the thirty-six regions was observed twice by each observer.

During the process of preparing the Rumford work for publication, it was found that there appeared to be differences in scale for the various observers participating in the work. For the purpose of more thoroughly investigating the causes of these differences, and to provide an entirely independent series of observations, which could serve as a means of intercomparison between the various observers, the regions north of the equator were measured by Mitchell and Alden in the years 1919, 1920, and 1921. The plan of measurement had many points of difference from that of the other observers, chief among which were:

(1) There were compared with the five standard stars of twelfth magnitude all of the stars of fourteenth, fifteenth and sixteenth magnitude, when not too faint to be seen with the twenty-six-inch refractor.

(2) Four photometric settings constituted a complete measure, and each star was measured twice, once direct and again in order reversed.

(3) The readings of the scale were recorded but were not read at the time. This was rendered possible by a simple recording device arranged as follows: Attached to the pinion that moved the wedge is a cylindrical drum about 45 millimeters in diameter and 120 millimeters in length. The surface of the drum was of hard rubber and was so arranged that a sheet of paper could be clamped tightly on it. As the pinion was turned to move the wedge the drum rotated. A stylus was arranged so that a record of the setting of the

wedge was made by simply pricking the paper with the stylus. After the completion of the measures on any particular star, the stylus was moved a slight amount by means of a screw so that the measures of the next star were recorded at a different place on the paper. In this manner the measures were recorded progressively along the cylindrical drum. This automatic method had several distinct advantages, chief of which were: (a) The eyes of the observer were not made insensitive, since no light was used to read the scale. (b) Measures could be recorded by the stylus much more quickly than a scale could be read by a reading lamp. (c) The measures were made entirely independently and without bias for the observer had no knowledge of how closely his individual settings of the photometer were agreeing, and hence he did not attempt to make the scale readings of his later observations agree with those already made. He would not make extra settings to replace discordant readings. Before the paper was removed from the cylindrical drum, points were punched on both edges of the sheet of paper to give the scale readings 0, 10, 20, etc. When removed from the drum the sheet was read off by a scale somewhat in the manner used with a chronograph sheet. Instead of reading each point recorded by the stylus the position was read giving the mean of the four settings.

(4) In order to save the time at the telescope which was busily employed in the determination of stellar parallax, the two observers, Mitchell and Alden, always observed together, and in the following manner: Each star to be measured was brought by Alden close to the image of the artificial star at the proper position for measurement. Four settings of the photometer were made by him. Four settings were immediately made by Mitchell. The next star was then brought to position by Alden and measured, and in like manner by Mitchell.

The record sheet was in all cases read off by Alden, and he also carried out all of the reductions and derived the magnitudes.

If it was possible to measure all of the stars, there were twenty stars in the series, and as the series of measures was carried out in direct and reversed order, 160 settings were made by each observer, or 320 by the two observers. About one hour was consumed in the measurement of each region, which is about equal to the time employed by an observer with a recorder in making 100 settings where it was necessary to read the scale.

The Calibration of the McCormick Wedge.

The calibration of the McCormick wedge merits a more detailed discussion since no details of the McCormick measurements have ever been published and because a different method has been used in handling and combining the data from which the calibration curves have been derived.

Considerable data concerning the absorption of the McCormick wedge had been accumulated in the years 1901–1905, both in the laboratory and at the telescope. The only reduction curve of the wedge derived from any of this data was that obtained by Professor Stone from six hundred settings by himself and Mr. Paddock. The observations were secured by means of a curtain having radial openings mounted on the telescope in such a manner that it could be drawn when desired in front of the objective by means of a cord. The size of the apertures was such that the brightness of any star would be cut down by two magnitudes when the curtain was over the objective. A comparison of the scale-readings on any given star for measures made with and without the curtain gave a means of finding the wedge 'constant' since the magnitude interval was known. The measures showed, however, that the so-called 'constant' was not a constant for different portions of the wedge although the wedge was designed to give uniform changes of magnitude for each unit increase in scale-reading.

If we let σ be the slope of the calibration curve at any scale-reading s, that is, the change in the absorption of the wedge, expressed in stellar magnitudes per scale division at the given scale-reading, this slope would be the 'constant' of the wedge if the relation between the absorption of the wedge and the scale-reading were linear. Since σ was not a constant, Professor Stone assumed that it bore a linear relation to the scale-reading and derived by least squares the coefficients of the formula expressing this relation as represented by the data mentioned. He obtained the expression

$$\sigma = +0^{m}.132 - 0^{m}.00080\ (s - 31.8)$$

which is given in the *Astrophysical Journal*, 22, 140, 1905. The calibration curve was derived from this relation by integration from $s=0$ to $s=60$.

An examination of the data showed that the absorption fell off considerably at the ends of the wedge and that the variation along the wedge was not so simple as that assumed by Professor Stone.

In September, 1914, Harold Lee Alden came to the McCormick Observatory as Vanderbilt fellow in Astronomy. The reduction of the Rumford work was undertaken by him, the whole material being left freely in his hands. The discussion following is taken from his dissertation. Although Mitchell and Alden took an equal part at the telescope in making the recent measurements of the Rumford regions, and in the laboratory and at the telescope made approximately the same number of observations to determine the calibration curve, the reductions for deriving the calibration curves and for deducing the stellar magnitudes have been made entirely by Alden.

Two separate methods of reduction are necessary for the McCormick observations.

First, to reduce the observations made by Curtis of the fifteenth magnitude standards, and those of Reed and Simpson of the fourteenth magnitude standards, these observations having been made between the years 1901 and 1904; and second, to reduce the recent measures of Mitchell and Alden of the stars from fourteenth to sixteenth magnitudes, inclusive.

Early McCormick Calibration Curve.

In discussing the available calibration data no assumptions were made regarding the manner in which the absorption per scale-division varied with the scale-reading. It was assumed that the average absorption over an interval of the wedge not too great was the same as the absorption at the mean scale-reading, and that in combining data from various series of observations within a limited interval of the wedge the weighted mean of the slopes corresponded to the weighted mean of the scale readings. It was also assumed that the calibration curve is a continuous function of the scale-reading or, in other words, that there are no *abrupt* changes in the density of the photographic wedge. The effect of these assumptions is to smooth off the resulting calibration curve in very much the same manner as is done by drawing a smooth curve through a number of observed points not in perfect agreement. It in no way affects the total absorption of the wedge from end to end. It averages out the little local irregularities in the wedge which are smaller than the errors of observation to which photometric measures are subject, unless the wedge is very imperfect. The great advantage of this method of discussion is that it facilitates the combination of various series of observations, and gives a better balanced system of weights when observations in the various series to be combined are not equally numerous in all parts of the wedge.

Recent investigations of the wedge which will be discussed later have shown that the calibration curve of the same wedge varies for different observers and that, theoretically at least, a separate curve should be derived for each observer. This could not be done with sufficient accuracy for the observers prior to 1905, so it was necessary to use a composite curve. It was decided to include also data derived by Mitchell and Alden since 1915, although this was done only after some hesitation because several changes had been made in the photometer which might affect the reduction curve. The addition of the recording device, the use of a new wedge carrier graduated in millimeters instead of twenty-fifths of an inch, which involves also a possible change in the zero-point of the wedge and the insertion of a smaller aperture for the artificial star, all seemed to make it inadvisable to use recent data for determining the form of the reduction curve to be used with the earlier measures. However, the large number of observations distributed more uniformly over the wedge were considered as of sufficient value to be included and they probably form

for the greater portion of the wedge by far the most reliable data. The recent measures were given relatively low weight so as not to affect preponderatingly the results.

The various series which enter into the determination of the composite reduction curve are as follows:—

Series I. Twelve hundred settings in the laboratory by Stone, Paddock, Reed and Simpson using a Lummer-Brodhun photometer and varying the distances of the light-sources to give known magnitude intervals. These observations were given relatively low weight as they were not made under conditions similar to those at the telescope.

Series II. About nine hundred settings in the laboratory by Stone, Paddock and Olivier using two shade glasses of known magnitude absorption and varying the position of the wedge in the photometer to produce equality when comparing with an artificial star with and without the shade glass interposed. The shade glasses were designated as I and II respectively. The absorption of these glasses in terms of stellar magnitudes was obtained by Curtis in the laboratory using a Lummer-Brodhun photometer. He obtained for shade I an absorption of 0.837 magnitude and for shade II the value of 0.859. Thus the two shades when used together gave a magnitude interval of 1.696 magnitudes. These values have been used in all the reductions. The absorption of shade I was also determined by Mitchell and Alden in the laboratory using an artificial star and a rotating sector cut with an angle which gave a reduction equal to the value derived by Curtis. A zero method was then used by measuring the brightness of the artificial star first with the shade glass interposed and then with the sector rotating before the star. An approximate value of the absorption of the wedge served to give with sufficient accuracy the slight correction to be applied to the absorption of the sector to obtain the absorption of the shade glass. The values obtained with their respective probable errors were for Mitchell, $0^m.827 \pm 0.004$, and for Alden, $0^m.838 \pm 0.004$. Giving all the values equal weight the mean of the three determinations for shade I is $0^m.834$. As this value differs from the value derived by Curtis by only about one third of one percent, his values have been used for both of the shades.

Series III. About eight hundred settings at the telescope by Stone, Paddock and Reed on stars in the Pleiades with and without one or both of the shade glasses just described placed in the cone of light from the real star. As a series of measures was first made without the shade glass on a number of the stars and then the measures repeated with the shade glass in, some time must have elapsed between the two sets of measures on a given star allowing possible changes in the transparency, seeing, brightness of photometer star, etc. Hence the results were assigned very low weight.

Series IV. About six hundred settings by Stone, Paddock and Reed similar to those

in Series III except that the measures with and without shade were made in succession on each star.

Series V. About a thousand settings by Curtis on the twelfth magnitude standards in the course of the measurement of the Rumford regions in a manner similar to that in Series III. The measures are confined to only half of the wedge toward the smaller scale readings. Had they been distributed uniformly throughout the wedge, a separate curve could have been derived for this observer.

Series VI. Six hundred settings by Stone and Paddock using the objective curtain. This is the series on which Professor Stone's formula and curve were based.

Series VII. This series consists of measures made by Parkhurst in the laboratory at Yerkes Observatory using a rotating sector, the method being similar to that used in the calibration of the Yerkes wedge.

Series VIII. About eleven hundred settings by Mitchell in the laboratory projecting an artificial star into the photometer. Of this number about three hundred were made with polarizing prisms to give known magnitude intervals. The remainder were made with a rotating sector having ten steps, each differing in absorption by about half a magnitude.

Series IX. Sixteen hundred settings by Alden made in the same manner as in Series VIII, eleven hundred being made with polarizing prisms and the remainder with the rotating sector.

Series X. About twenty-five hundred settings by Mitchell at the telescope made in the same manner as the observations in Series IV except that shade I only was used.

Series XI. Same as Series X except by Alden.

The values of the slope for each five scale divisions were combined to form a normal point. These mean values of σ were plotted as ordinates with the mean scale readings as abscissae and a smooth curve drawn through these points. This curve showed the manner in which the slope of the calibration curve varied with the scale reading. The values of σ were read off the curve for each scale reading and the calibration curve formed by summation from $s=0$ to $s=60$.

In view of the large number of independent observations which enter into the determination of the above calibration curve it might seem proper to use it also for reducing the recent observations. However, on account of the changes in the adjustment of the photometer already specified, a separate curve was derived from the data of the last four series. This curve differed somewhat from the composite curve but the difference was not sufficient to warrant the belief that any marked changes had taken place in the wedge in the intervening years.

The mean curve based on the measures of Mitchell and Alden was first used for the reduction of miscellaneous photometer measures made by them since 1915, but it soon appeared that there was a systematic difference of scale between the two observers due entirely to personal equation in the estimation of equality for stars of different brightness. The calibration data of Mitchell and Alden were then separated and a reduction curve derived for each observer.

Though the details are not published here, the observations for each observer were separated into two series, one containing all of the measures made in the laboratory and the other all measures made at the telescope. In each set of measures made in the laboratory every precaution was taken to insure conditions as nearly approaching the actual conditions at the telescope as possible.

At the telescope the calibration curve was determined by measuring stars of different magnitudes both with and without the shade glass. No assumptions need be made regarding the magnitudes of the stars measured. The absorption of the wedge depends on the value assumed for the absorption of the shade glass, but this is known within one percent. The calibration curve depends on the assumption that the absorption of the shade glass is constant for stars of all magnitudes. There is another possible source of systematic error in that the shade glass may not be perfectly neutral tinted, and consequently it may have a different absorption for a red star than for a blue star. However, the results are based on measures made on many nights under various conditions of seeing and adjustments of the photometer and extending over a period of five years. Any systematic errors will therefore probably disappear. There is a very satisfactory agreement between values obtained in the laboratory and at the telescope. The calibration curve for Alden and for Mitchell is a combination of both methods.

In Table VI are given the values for the absorption of the McCormick wedge. Observations made prior to 1905 were reduced by the values in the column headed "Early."

Justification for the use of the separate curves for Mitchell and for Alden can be shown independently of any known magnitudes or reduction curves. As already stated the photometer observations with the McCormick telescope have been carried on simultaneously by both observers. They are therefore subject to the same conditions of seeing and photometer adjustment. If there were no personal difference of measurement the scale readings of the two observers would on the average be the same for a given star. This is not the case. Since the scale readings of the two observers are strictly comparable in every way a direct comparison will show systematic differences if they exist. Taking the difference between the scale readings in the sense Mitchell minus Alden and tabulating these for every five scale divisions according to the scale reading of the stars as obtained

by Alden we obtain the results given in Table VII. This is based on the measures of five hundred and eighty stars picked at random from the photometer record book covering measures made during a period of a year and a half and well distributed throughout the wedge.

TABLE VI.

McCormick Calibration Curve.

Scale	Early	Recent		Scale	Early	Recent		Scale	Early	Recent	
		A	M			A	M			A	M
1	0.05	0.05	0.05	21	2.40	2.56	2.32	41	4.73	4.85	4.80
2	0.11	0.12	0.11	22	2.52	2.69	2.45	42	4.84	4.95	4.91
3	0.18	0.20	0.18	23	2.64	2.82	2.58	43	4.94	5.05	5.02
4	0.26	0.29	0.26	24	2.76	2.94	2.71	44	5.04	5.15	5.13
5	0.34	0.39	0.34	25	2.88	3.06	2.84	45	5.14	5.25	5.23
6	0.43	0.50	0.43	26	2.99	3.18	2.97	46	5.24	5.34	5.33
7	0.53	0.61	0.52	27	3.10	3.30	3.10	47	5.33	5.43	5.43
8	0 64	0.73	0.62	28	3.21	3.42	3.23	48	5.42	5.51	5.53
9	0.75	0.86	0.73	29	3.32	3.54	3.35	49	5.51	5.59	5.63
10	0.87	0.99	0.84	30	3.43	3.66	3.47	50	5.60	5.67	5.73
11	1.00	1.13	0.96	31	3.55	3.77	3.59	51	5.69	5.75	5.83
12	1.13	1.28	1.09	32	3.67	3.88	3.71	52	5.77	5.83	5.93
13	1.27	1.43	1.23	33	3.79	3.99	3.83	53	5.85	5.91	6.03
14	1.41	1 58	1.37	34	3.91	4.10	3.95	54	5.93	5.98	6.12
15	1.56	1.73	1.51	35	4.03	4.21	4.07	55	6.01	6 05	6.21
16	1.71	1.88	1.65	36	4.15	4.32	4.19	56	6.09	6.12	6.30
17	1.86	2.02	1.79	37	4.27	4.43	4.32	57	6.16	6.19	6.39
18	2 00	2.16	1.93	38	4.39	4.54	4.45	58	6.23	6.25	6.48
19	2.14	2.30	2.06	39	4 51	4.65	4.57	59	6.30	6.31	6.57
20	2.27	2.43	2.19	40	4.62	4.75	4 69	60	6.37	6.37	6.66

Column one contains the mean reading on the scale. This is assumed to be the mean of the limits within which the observations are grouped which will be sufficiently accurate for the purpose. Column two gives the number of stars contained in the group and column three the average difference between the scale readings of Mitchell and Alden. This difference is sensibly constant down to thirty-five on the wedge but diminishes thereafter and actually changes sign.

The calibration curves derived should provide for this systematic difference in setting. In column four of Table VII is entered the absorption from Alden's curve for the scale reading in column one. The fifth column contains the absorption from Mitchell's curve for the same scale-reading corrected for the average difference in column three. Five hundredths of a magnitude has been subtracted from each value in this column for a

difference in zero point which would be taken care of by any method of reduction. Column six gives the difference between the magnitudes in columns four and five. These quantities represent the differences between the average final magnitudes of these stars as determined by the two observers, leaving out of account any differences introduced by peculiarities of measurement of the particular stars which are used for standards. It shows that the present curves will on the average give the same magnitudes for Mitchell and Alden within about two hundredths of a magnitude.

TABLE VII.

Comparison of Settings, Mitchell and Alden.

Mean scale reading	No. of stars	$S_M - S_A$	Δ Magn. Alden	Δ Magn. Mitchell	Δ Magn. M − A
8.6	6	+1.6	0.81	0.81	0.00
12.5	37	+2.0	1.36	1.39	+ .03
17.5	58	+1.9	2.09	2.06	− .03
22.5	52	+2.1	2.76	2.74	− .02
27.5	54	+2.4	3.36	3.41	+ .05
32.5	63	+1.9	3.94	3.95	+ .01
37.5	85	+0.8	4.48	4.44	− .04
42.5	77	+0.5	5.00	4.97	− .03
47.5	58	+0.4	5.47	5.47	.00
52.5	62	−0.7	5.87	5.86	− .01
57.0	28	−1.3	6.19	6.22	+ .03

This seems to demonstrate the necessity for the separate reduction curves and to show also that should the photometer be used with a different telescope where the personal equation might be different a separate calibration curve should be derived. If possible this should be done at the telescope although it is very difficult to obtain known differences of magnitude at the telescope in a way which insures that no systematic error is being introduced. The use of 'known' (?) magnitudes of stars has the objection that it makes the calibration curve of one observer depend upon the personal equation and color curve of the observer of the adopted magnitudes as well as upon his own.

The conclusion is obvious, however, since the observations of Mitchell and Alden are made under precisely the same conditions and require different calibration curves, that the calibration curve of the wedge is dependent on the physiological or psychological peculiarities of the observer as well as the density of the wedge.

In Table VIII are given the results of the measures of the stars of fourteenth magnitude by T. McN. Simpson and F. W. Reed; in Table IX the fifteenth magnitude stars by Heber D. Curtis; and in Table X are the more recent observations by S. A. Mitchell and Harold L. Alden.

TABLE VIII.

McCormick Measures. Fourteenth Magnitude.

	S Ceti					*U Cassiopeiae*					*S Piscium*				
	1903 Sept. 18	1903 Sept. 28	1903 Sept. 29	1903 Sept. 30	Mean Magn.	1903 Oct. 27	1904 Jan. 16	1904 Jan. 16	1904 Feb. 6	Mean Magn.	1903 Dec. 17	1903 Dec. 17	1904 Jan. 9	1904 Jan. 18	Mean Magn.
Obs Seeing Shade	*S* *f*	*S* *g*	*R* *g*	*R* *g*		*S* *g* 1.70	*S* *vg*	*R* *vg*	*R* *vg* 0.84		*R* *vg*	*S* *vg* 0.84	*R* *g*	*S* *g* 0.84	
Mo	8.79	11.12	10.56	9.24		11.18	9.87	10.06	11.76		10.66	10.66	10.48	10.22	
A	12.39	.15	.38	.36	12.32	12.14	*.95*	.17	.02	12.07	11.46	.36	.54	.30	11.42
B	12.62	.53	.33	.56	12.51	11.85	.76	.56	.74	11.73	11.65	.56	.52	.90	11.66
C	12.40	.59	.55	.56	12.52	12.22	.22	.29	.12	12.21	12.00	*.90*	*.69*	.15	11.94
D	12.68	.71	.95	.65	12.75	11.90	.93	*.12*	*.16*	12.03	11.86	.97	.94	.61	11.84
E	12.93	*.05*	.83	.89	12.92	12.19	.43	.17	.25	12 26	12.07	.22	.34	.04	12.17
F	13.49	.78	.89	.85	13.75	13.11	.32	*.93*	.16	13.13	13.18	.41	.19	.36	13.28
G	13.88	*.20*	.99	*.02*	14.02	13.41	.29	.60	.41	13.43	13.85	.41	.76	.58	13.65
H	13.99	*.23*	.95	*.24*	14.10	13.45	.31	.57	.46	13.45	13.82	.82	.86	.99	13.87
J	14.30	.50	.07	.13	14.25	13.32	.52	.68	.47	13.50	13.89	.89	*.19*	.87	13.96
K	14.—	.46	.23	.10	14.26	13.70	.56	.81	.75	13.70	14.20	.10	.23	.32	14.21

	S Cassiopeiae						*R Ceti*					*U Arietis*				
	1904 Mar. 16	1904 Sept. 10	1904 Sept. 10	1904 Oct. 1	1904 Oct. 1	Mean Magn.	1903 Nov. 19	1903 Dec. 11	1903 Dec. 11	1903 Dec. 18	Mean Magn.	1904 Jan. 18	1904 Jan. 18	1904 Feb. 5	1904 Feb. 6	Mean Magn.
Obs. Seeing Shade	*R* *vg*	*R* *g*	*S* *vg*	*R* *vg* 0.84	*S* *vg* 0.84		*R* *vg* 1.70	*S* *vg*	*R* *vg*	*S* *g* 0.84		*R* *vg*	*S* *g*	*R* *vg* 0.84	*S* *g* 0.84	
Mo	10.10	11.09	10.50	11.29	11.04		13.12	10.78	10.73	11.56		10.96	10 .52	11.95	11.68	
A	11.84	.58	.63	.50	.47	11.60	12.42	.11	.19	.25	12.24	12.85	.84	.65	.67	12.75
B	11.48	.50	.66	.55	.79	11.60	12.37	.40	.55	.32	12.41	12.90	*.05*	.85	.92	12.93
C	11.54	.53	.69	.61	.51	11.58	12.52	.46	.50	.49	12.49	13.13	.28	.38	.08	13.22
D	11.75	*.04*	.59	.97	.68	11.81	12.55	.72	.50	.78	12.64	13.20	.16	.11	.14	13.15
E	12.27	.22	.28	.22	.42	12.28	12.75	.91	.87	.78	12.83	13.11	*.82*	.19	.34	13.12
F	13.44	.19	.10	.35	.35	13.29	14.25	.13	.47	.19	14.26	13.82	.72	.92	*.16*	13.90
G	13.39	.20	.22	.26	.40	13.29	14.70	.22	.98	.34	14.56	13.93	*.14*	.98	*.14*	14.05
H	13.75	.49	.38	.32	.45	13.48	14.68	.86	*.08*	.58	14.80	14.15	.00	.03	.33	14.13
J	13.61	.48	.28	.25	.79	13.48	14.76	*.32*	*.11*	.74	14.98	14.38	*.93*	.17	.06	14.14
K	14.12	——	*.91*	*.56*	*.79*	13.84	14.80	*.19*	*.24*	.75	15.00	14.58	.54	.59	.64	14.59

McCormick Measures. Fourteenth Magnitude.

	R Persei					*V Tauri*					*S Orionis*				
	1904 Feb. 6	1904 Feb. 15	1904 Feb. 17	1904 Feb. 17	Mean Magn.	1904 Mar. 18	1904 April 4	1904 Sept. 16	1904 Sept. 16	Mean Magn.	1904 Feb. 5	1904 Feb. 15	1904 Feb. 17	1904 Feb. 17	Mean Magn.
Obs.	*R*	*S*	*S*	*R*		*S*	*R*	*R*	*S*		*S*	*R*	*S*	*R*	
Seeing	*vg*	*g*	*g*	*g*		*g*	*vg*	*g*	*vg*		*vg*	*vg*	*vg*	*g*	
Shade	0.84	0.84	1.70	1.70		0.84					0.84	0.84	1.70	1.70	
Mo	11.17	10.88	12.44	12.24		11.40	10.40	11.69	11.44		11.35	11.35	12.36	12.12	
A	11.36	.09	.12	.31	11.22	12.53	.40	.43	.23	12.40	12.13	.16	.07	.85	12.05
B	11.71	.91	.84	.60	11.76	12.70	.67	.50	.97	12.71	11.61	.59	.58	.70	11.62
C	11.54	.66	.75	.73	11.67	12.24	.37	.72	.31	12.41	11.64	.59	.74	.69	11.66
D	11.60	.78	.49	.62	11.62	12.21	.44	.24	.18	12.27	12.07	*.97*	*.96*	*.99*	12.00
E	11.83	.60	.86	.81	11.78	12.55	.37	.34	.54	12.45	11.67	.81	.79	.89	11.79
F	13.43	.02	.19	.25	13.22	13.81	.51	.75	.59	13.66	13.22	.31	.37	.11	13.25
G	13.68	.34	.47	.36	13.45	13.85	.34	.87	.61	13.67	13.27	.29	.48	.15	13.30
H	13.64	.38	.56	.24	13.46	14.00	*.87*	*.97*	*.61*	13.86	13.29	.41	.55	.17	13.36
J	13.79	.27	.57	.38	13.50	13.94	.90	*.16*	.92	13.98	13.36	.52	.50	.08	13.36
K	13.54	.90	.97	.90	13.83	14.23	.01	.22	.10	14.14	13.34	.55	.64	.22	13.44

	V Aurigae					*R Geminorum*					*U Puppis*				
	1904 Feb. 16	1904 Feb. 16	1904 Feb. 19	1904 Feb. 19	Mean Magn.	1904 Jan. 25	1904 Jan. 25	1904 Jan. 26	1904 Jan. 26	Mean Magn.	1904 April 4	1904 April 4	1904 April 16	1904 April 18	Mean Magn.
Obs.	*R*	*S*	*S*	*R*		*R*	*S*	*R*	*S*		*S*	*R*	*R*	*S*	
Seeing	*vg*	*vg*	*g*	*vg*		*vg*	*vg*	*vg*	*vg*		*g*	*g*	*g*	*f*	
Shade	0.84	0.84											0.84		
Mo	11.45	11.04	10.50	11.10		10.66	10.24	10.99	10.25		9.87	10.00	10.65	9.53	
A	11.99	*.06*	.66	.90	11.90	11.93	.87	.90	.80	11.88	11.28	.19	.31	.12	11.22
B	12.58	.40	.44	.57	12.50	11.64	.76	.64	.77	11.70					*i*
C	12.21	.09	.36	.09	12.19	12.18	.16	.16	.31	12.17	11.70	.60	.70	.72	11.68
D	12.31	.57	.53	.41	12.46	12.04	*.99*	.13	.01	12.04	11.25	.37	.27	.24	11.28
E	12.39	.37	.50	.51	12.44	12.36	.17	.55	.34	[12.36]*l*	11.46	.53	.39	.59	11.49
F	13.59	.44	.04	.58	13.41	12.88	.68	.79	.52	12.72	13.04	.26	.46	.27	13.26
G	13.63	.50	.24	.57	13.48	12.91	.73	.86	.56	12.76	13.17	.40	.41	.13	13.28
H	13.65	.51	.28	.75	13.55	13.00	*.74*	.00	*.79*	12.88	13.19	.57	.60	.36	13.43
J	13.72	.78	.32	.51	13.58	13.21	*.93*	.16	*.96*	13.06	13.32	.63	.65	.51	13.53
K	13.93	.60	.31	.70	13.64	14.33	.13	.13	.17	14.19	13.44	.65	.74	.82	13.66

i Hagen 82 measured by Professor E. C. Pickering.
l Star E is the variable Z Geminorum. Not used as standard.

McCormick Measures. Fourteenth Magnitude.

	V Cancri					*T Hydrae*					*R Leonis Minoris*						
	1904 Feb. 22	1904 Feb. 22	1904 Mar. 7	1904 Mar. 16	Mean Magn.	1904 April 16	1904 May 4	1904 May 4	1904 May 5	Mean Magn.	1904 April 18	1904* Apr. 19	1904 Apr. 20	1904* Apr. 20	1904 Apr. 21	1904 May 11	Mean Magn.
Obs.	*R*	*S*	*R*	*S*		*S*	*R*	*S*	*R*		*R*	*R*	*R*	*S*	*S*	*S*	
Seeing	*vg*	*g*	*vg*	*vg*		*g*	*g*	*g*	*g*		*g*	*vg*	*g*	*p*	*g*	*vg*	
Shade	0.84	0.84				0.84							0.84	0.84	0.84	0.84	
Mo	11.56	11.11	11.02	10.75		11.11	10.56	10.18	11.21		10.43	10.69	11.76	11.18	11.91	11.78	
A	11.68	.71	.68	.62	11.67	11.55	.76	.77	.68	11.69	12.50	.41	.45	.40	.37	.38	12.42
B	12.07	*.95*	*.96*	.08	12.02	12.03	*.91*	*.78*	*.85*	11.89	12.57	.84	.79	.67	.71	.35	12.66
C	11.92	.92	.82	.89	11.89	12.10	.18	*.95*	.18	12.10	13.05	*.96*	*.88*	*.98*	.08	.17	13.02
D	12.32	.10	.40	.34	12.29	11.98	.97	*.02*	*.11*	12.02	12.94	.70	.86	*.02*	.85	*.13*	12.92
E	12.28	.59	.40	.34	12.40	12.27	.09	.37	08	12.20	13.19	.35	.29	.18	.24	.24	13.25
F	13.06	.26	.20	.05	13.14	13.65	.58	.81	.41	13.61	13.73	.70	.56	.67	.69	.61	13.65
G	13.33	.37	.20	*.94*	13.21	13.69	.58	*.03*	.48	13.70	13.57	.78	.58	.76	.78	.65	13.67
H	13.50	.59	.58	.32	13.50	13.98	.82	*.09*	.60	13.87	13.86	.53	.77	.66	.97	.84	13.81
J	13.52	.52	.42	.69	13.54	14.01	*.82*	.25	*.56*	13.91	14.60	.54	.34	.46	.66	.69	14.56
K	13.63	.51	.42	.65	13.55	14.17	.22	.20	.01	14.15	14.69	.59	.35	.67	.63	.75	14 61

	W Leonis					*T Virginis*					*T Ursae Majoris*				
	1904 Jan. 25	1904 Jan. 25	1904 Jan. 26	1904 Jan. 26	Mean Magn.	1904 Feb. 12	1904 Feb. 12	1904 Feb. 16	1904 Feb. 16	Mean Magn.	1904 Feb. 19	1904 Feb. 19	1904 May 11	1904 May 18	Mean Magn.
Obs.	*R*	*S*	*R*	*S*		*R*	*S*	*R*	*S*		*S*	*R*	*R*	*S*	
Seeing	*vg*	*g*	*vg*	*vg*		*vg*	*f*	*g*	*g*		*p*	*p*	*g*	*f*	
Shade						0.84	0.84	0.84	0.84		0.84	0.84			
Mo	9.77	9.74	10.20	11.06		11.87	11.82	10.63	10.61		10.98	12.28	11.06	9.50	
A	12.29	.38	.47	.56	12.42	11.68	.43	.68	.77	11.64	12.62	.65	.66	.53	12.62
B	12.39	.39	.31	.47	12.39	11.77	*.08*	.56	.76	11.79	12.49	.64	.80	.73	12.66
C	12.48	.71	.57	.53	12.57	12.03	*.95*	.11	*.88*	11.99	13.43	.21	.25	.18	13.27
D	12.76	.50	.73	.65	12.66	12.06	*.75*	.11	.17	12.02	13.32	.36	.14	.41	13.31
E	13.02	*.94*	*.85*	*.71*	12.88	12.22	.57	.33	.19	12.33	——	—	—	—	——
F	13.69	.70	.81	.66	13.72	13.39	.75	.44	.35	13.48	13.25	.61	.54	.53	13.48
G	14.05	.08	*.98*	*.76*	13.97	13.64	.81	.31	.38	13.53	13.79	*.06*	.97	.94	13.94
H	13.98	*.19*	.94	.78	13.97	13.84	*.51*	*.04*	.81	14.05	14.08	.10	*.77*	.16	14.03
J	14.31	.63	.30	.24	14.37	13.93	*.50*	*.19*	.90	14.13	14.14	.60	.62	.66	14.50
K	14.42	.75	.52	.25	14.48	14.09	.54	.19	*.97*	14.20	14.58	.80	.66	.88	14.73

* Series of measures incomplete. Measures on faint stars given half weight.

McCormick Measures. Fourteenth Magnitude.

	U Virginis					*S Virginis*					*S Bootis*				
	1904 Feb. 24	1904 Feb. 24	1904 Mar. 16	1904 Mar. 16	Mean Magn.	1904 Feb. 24	1904 April 16	1904 April 16	1904 May 11	Mean Magn.	1904 Oct. 6	1904 Oct. 6	1904 Oct. 7	1905 Oct. 21	Mean Magn.
Obs.	*R*	*S*	*R*	*S*		*R*	*R*	*S*	*S*		*S*	*R*	*S*	*R*	
Seeing	*g*	*f*	*vg*	*vg*		*vg*	*vg*	*vg*	*vg*		*f*	*g*	*f*	*vg*	
Shade	0.84	1.70	0.84	0.84		0.84			0.84		0.84		0.84		
Mo	11.87	11.31	11.13	11.28		11.77	10.59	10.91	11.45		12.40	10.33	12.43	9.93	
A	11.69	.55	.50	.68	11.60	12.12	.07	.32	*.94*	12.11	12.53	.27	.25	.11	12.29
B	11.48	.44	.38	.68	11.50	12.01	.25	.18	.31	12.19	12.46	.40	.65	.47	12.50
C	12.19	.49	.23	.24	12.29	12.45	.33	.32	.38	12.37	12.52	.69	.62	.83	12.66
D	12.44	.23	.53	.44	12.41	12.76	.65	.63	.58	12.66	12.70	.73	.94	.85	12.80
E	12.65	.70	.81	.37	12.63	12.89	.93	.77	.98	12.89	12.80	.95	.54	.76	12.76
F	13.39	.88	.37	.31	13.49	13.90	.71	.56	.63	13.70	13.68	.95	*.17*	.90	13.92
G	13.49	.82	.44	.69	13.61	13.84	.90	.74	.93	13.85	13.71	*.02*	.85	*.14*	13.93
H	13.61	.94	.58	.46	13.65	14.04	*.97*	*.95*	.15	14.03	13.99	.89	*.11*	.92	13.98
J	14.19	—	*.87*	*.94*	14.00	14.29	.09	*.97*	.11	14.11	14.04	.35	.37	.21	14.24
K	13.94	*.44*	*.00*	.86	14.06	14.35	.33	.23	.53	14.36	14.18	.44	.37	—	14.33

	R Camelopardalis					*R Serpentis*					*RR Librae*				
	1901 Oct. 3	1904 Oct. 3	1904 Nov. 30	1904 Nov. 30	Mean Magn.	1904 May 18	1904 May 18	1904 July 6	1904* Sept. 12	Mean Magn.	1904 April 21	1904 April 21	1904 May 5	1904 May 5	Mean Magn.
Obs.	*R*	*S*	*R*	*S*		*R*	*S*	*R*	*S*		*R*	*S*	*S*	*R*	
Seeing	*g*	*g*	*vp*	*vp*		*g*	*g*	*vg*	*vp*		*g*	*g*	*g*	*g*	
Shade	0.84	0.84	0.84	0.84					1.70				0.84	0.84	
Mo	11.89	11.87	11.66	11.75		10.55	9.97	10.69	11.81		10.51	10.32	10.45	10.65	
A	11.54	.45	.74	.74	11.62	11.55	.56	.55	.63	11.57	11.52	.37	.57	.68	11.54
B	12.18	.24	.06	.21	12.17	11.55	.39	.36	.06	11.34	11.54	.66	.64	.70	11.64
C	12.35	.13	.46	.05	12.25	11.52	.47	.54	.73	11.56	11.74	.56	.55	.55	11.60
D	12.61	.63	.58	.62	12.61	11.81	.87	*.04*	*.08*	11.95	11.70	.56	.75	.52	11.63
E	12.61	.83	.47	.69	12.65	12.26	.42	.22	.19	12.27	11.55	.90	.53	.58	11.64
F	13.49	.74	.52	.61	13.59	13.59	.59	.17	.11	13.40	12.—	.95	.76	*.10*	12.94
G	13.79	*.33*	.79	*.06*	13.99	13.87	.70	.26	.49	13.59	13.26	.04	.17	.43	13.22
H	13.86	*.27*	*.11*	.85	14.02	13.78	.99	.66	*.11*	13.85	13.62	.55	.89	.64	13.68
J	13.86	*.51*	.97	*.05*	14.10	13.97	*.18*	.58	*.08*	13.93	13.58	*.01*	.91	.83	13.83
K	13.90	*.34*	*.03*	*.19*	14.12	14.21	.06	*.56*	*.84*	13.93	14.05	.33	.42	.24	14.26

* Series of measures incomplete. Measures on faint stars given half weight.

McCormick Measures. Fourteenth Magnitude.

	R and S Scorpii					*W Herculis*					*R Draconis*				
	1904 April 19	1904 April 19	1904 April 20	1904 April 20	Mean Magn.	1904 May 4	1904 May 4	1904 May 5	1905 May 5	Mean Magn.	1904 May 12	1904 May 18	1904 May 18	1904 Oct. 1	Mean Magn.
Obs.	*S*	*R*	*R*	*S*		*R*	*S*	*S*	*R*		*S*	*S*	*R*	*R*	
Seeing	*g*	*g*	*vg*	*g*		*g*	*g*	*g*	*g*		*f*	*vg*	*g*	*vg*	
Shade	0.84		0.84	0.84					0.84		1.70	0.84	0.84	0.84	
Mo	10.78	10.95	11.13	10.50		10.72	9.67	10.55	11.06		11.69	10.86	10.51	11.01	
A	12.17	*.90*	*.85*	*.72*	11.91	11.45	.67	.58	.55	11.56	11.23	.29	.54	.47	11.38
B	11.93	*.09*	.97	*.25*	12.06	11.62	.70	.64	.84	11.70	11.37	*.02*	.74	.65	11.70
C	11.83	*.00*	.97	.90	11.92	11.58	.47	.51	.48	11.51	12.53	.13	.02	.24	12.23
D	12.11	.05	.32	.25	12.18	11.96	.75	.67	.78	11.79	12.43	.37	.35	.37	12.38
E	12.50	.47	.43	.40	12.45	11.99	*.04*	*.23*	.99	12.06	12.64	.39	.53	.44	12.50
F	13.08	.35	.10	.30	13.21	13.49	*.10*	.65	.72	13.74	13.87	.45	.58	.58	13.62
G	13.19	.26	.19	.50	13.28	13.90	*.14*	.84	.96	13.96	14.43	.10	*.91*	*.82*	14.07
H	13.20	.48	.33	.26	13.32	13.76	*.31*	.98	*.00*	14.01	14.64	.07	*.96*	.13	14.20
J	13.30	.55	.43	.59	13.47	13.83	*.30*	*.00*	*.02*	14.04	14.44	.37	*.99*	.19	14.25
K	13.82	.75	.77	.91	13.81	13.81	*.28*	.98	*.13*	14.05	14.85	.64	.18	.23	14.48

	S Herculis					*R Aquilae*					*Z Sagittarii*				
	1904 May 11	1904 May 11	1904 Oct. 10	1904 Oct. 10	Mean Magn.	1903 June 29	1903 June 30	1903 Oct. 13	1904 Oct. 6	Mean Magn.	1903 Sept. 12	1903 Sept. 15	1903 Sept. 21	1903 Sept. 25	Mean Magn.
Obs.	*R*	*S*	*S*	*R*		*S*	*S*	*R*	*R*		*S*	*S*	*R*	*R*	
Seeing	*g*	*vg*	*g*	*f*				*g*	*vg*				*vg*	*g*	
Shade		0.84		0.84		1.70	1.70							1.70	
Mo	9.93	11.04	10.94	9.56		11.00	11.11	9.93	10.27		8.23	9.62	8.53	10.63	
A	11.31	.30	.22	.31	11.28	11.41	.63	.70	.43	11.54	10.40	.81	.53	.63	10.59
B	11.34	.30	.46	.58	11.42	11.86	.93	.89	.80	11.87	10.77	*.03*	*.09*	.93	10.96
C	11.55	.58	.32	.63	11.52	11.78	.59	.67	.87	11.73	11.01	.09	.24	.10	11.11
D	11.94	*.17*	*.62*	.98	12.18	11.92	.83	.73	.91	11.85	11.48	.20	.15	.53	11.34
E	11.86	.64	.39	.52	11.60	11.94	.94	.90	.89	11.92	11.76	.33	.42	.23	11.44
F	12.96	*.57*	*.45*	.36	13.34	13.14	*.77*	.41	*.99*	13.08	12.43	*.99*	.86	.15	12.36
G	13.22	.50	.45	.25	13.36	13.45	*.95*	.52	.09	13.25	12.78	.53	*.37*	.77	12.86
H	13.44	.40	.59	.66	13.52	13.28	.25	.47	.04	13.26	12.88	.64	*.43*	.52	12.87
J	13.64	.76	.63	.43	13.62	13.31	.58	*.38*	.59	13.72	13.03	*.87*	.43	*.57*	12.98
K	13.86	.87	*.26*	*.30*	14.07	13.77	.55	*.20*	.38	13.72	13.85	.81	.98	.34	13.74

McCormick Measures. Fourteenth Magnitude.

	χ Cygni					*R Vulpeculae*					*V Capricorni*				
	1903 Oct. 13	1903 Oct. 19	1903 Oct. 20	1903 Oct. 26	Mean Magn.	1903 Nov. 18	1903 Nov. 19	1903 Nov. 20	1903 Dec. 18	Mean Magn.	1903 Oct. 19	1903 Oct. 21	1903 Oct. 21	1903 Nov. 18	Mean Magn.
Obs.	*S*	*R*	*R*	*S*		*S*	*S*	*R*	*R*		*S*	*R*	*S*	*R*	
Seeing	*g*	*g*	*vg*	*vg*		*vg*	*vg*	*vg*	*vg*		*g*	*g*	*g*	*vg*	
Shade	1.70		1.70			1.70	1.70	1.70	1.70			1.70	1.70	0.84	
Mo	11.16	9.81	11.41	10.29		10.54	10.98	11.04	10.74		9.91	11.74	10.44	10.45	
A	11.01	*.85*	*.73*	*.77*	10.84	10.70	.68	.64	.76	10.70	10.76	.83	.77	.62	10.74
B	10.76	*.04*	*.04*	*.04*	10 97	10 32	.65	.48	.39	10.46	11.26	.17	.22	.11	11.20
C	10 86	*.06*	.97	*.38*	11.07	10.55	.40	.64	.63	10.56	11.39	.07	.30	.20	11.24
D	11.28	.22	.30	.28	11 27	11.06	*.96*	*.98*	.04	11 01	11.18	.46	.24	.44	11.33
E	11.65	.36	.48	.05	11.38	10 84	.78	.71	.66	10.75	11.22	.28	.31	.41	11.30
F	11.94	.88	*.28*	*.04*	12.04	12.36	.39	.31	.54	12.40	13.32	.38	.18	.41	13.32
G	12.52	.31	.20	.17	12.30	12.44	.46	.44	——	12.45	13.58	.40	.40	.56	13.48
H	12.42	.20	.41	.39	12.36	12.38	.63	.46	.77	12.56	13.56	.93	.40	.46	13.59
J	12 97	.61	*.00*	.60	12 80	12.71	.76	.60	*.02*	12 77	13.82	.98	.70	.76	13.82
K	13.01	*.70*	*.99*	*.90*	12 91	12.81	.90	.82	*.13*	12.92	14.14	*.48*	*.80*	*.84*	13 82

	R Lacertae					*S Aquarii*					*R Pegasi*					
	1904 Jan. 13	1904 Feb. 3	1904 Feb. 4	1904 Feb. 4	Mean Magn.	1904 Oct. 3	1904 Oct. 3	1904 Oct. 6	1904 Oct. 6	Mean Magn.	1903 Sept. 25	1903 Oct. 14	1903 Oct. 20	1903* Oct. 26	1903 Oct. 27	Mean Magn
Obs.	*R*	*S*	*S*	*R*		*R*	*S*	*S*	*R*		*S*	*R*	*S*	*R*	*R*	
Seeing	*vg*	*vg*	*vg*	*vg*		*vg*	*vg*	*g*	*g*		*vg*	*vg*	*g*	*vg*	*g*	
Shade			0.84			0.84	0.84	0.84	0.84		1.70				1.70	
Mo	9.37	10.95	11.29	11.06		11.17	11.17	10.01	9.99		12.30	10.76	11.17	10.59	11.30	
A	11.99	*.01*	*.02*	*.09*	12 03	11.32	*.69*	.21	.21	11.11	11.63	.59	.62	.82	.64	11.66
B	12.37	.39	.32	.25	12.33	10.95	.90	.68	*.15*	10.92	11.87	*.23*	.74	.89	*.14*	11.97
C	12 38	.45	.31	.15	12.32	11.81	*.11*	*.01*	.79	11.93	11.98	*.03*	*.09*	.97	.82	11.98
D	12.18	.25	.55	.56	12 38	11.87	*01*	.91	.72	11 88	11.81	.66	.89	.78	.73	11.77
E	12 49	.29	.22	.33	12.33	11.86	*.07*	*.01*	.93	11.97	12.40	.16	.33	.21	.34	12.29
F	13.11	*.88*	.16	*.95*	13 02	13.10	.31	.63	.50	13.38	13.46	.47	.52	.30	.52	13.47
G	13.32	*.91*	.03	.05	13 08	13 79	.89	.96	.82	13.86	13.53	.46	.65	.36	.47	13.51
H	13 39	29	.11	.42	13 30	13.71	*.16*	*15*	*.00*	14.00	13.38	.59	.67	.36	.53	13.52
J	13 84	.10	.43	.57	13.48	13 88	*.19*	*29*	*.18*	14.14	13.47	.87	.56	.36	.56	13.59
K	13 75	.27	.46	.72	13.55	13 97	*.27*	*.41*	*.38*	14 24	13.77	.90	.59	.91	.61	13.74

* Series of measures incomplete. Measures on faint stars given half weight.

TABLE IX.

McCormick Measures. Fifteenth Magnitude.

	S Ceti				*U Cassiopeiae*				*S Piscium*			
	1901 Oct. 18	1901 Oct. 31	1901 Nov. 2	Mean Magn.	1901* Oct. 9	1901*a* Oct. 22	1902 June 8	Mean Magn.	1901 Nov. 2	1901 Nov. 6	1901 Nov. 8	Mean Magn.
Seeing Shade	*vg*	*g*	*vg*		*vg*	*g*	*vg* 0.84		*vg*	*vg*	*vg*	
Mo	8.86	9.35	9.68		10.11	8.41	10.77		10.09	10.30	9.69	
A	12.49	.19	.42	12.37	12.08	.31	.25	12.21	11.21	.16	.31	11.23
B	12.40	.39	.39	12.39	11.91	.62	.67	11.73	11.53	.57	.66	11.59
C	12.71	.63	.52	12.62	12.12	.46	.04	12.21	11.92	.86	.87	11.88
D	12.81	*.14*	.80	12.92	11.97	.94	*.08*	12.00	12.83	*.19*	.73	[12.92]*b*
E	12.61	.70	.89	12.73	12.21	*.97*	.28	12.15	12.41	.47	.23	12.37
L	13.37	.45	.46	13.43	13.—	.27	.41	13.34	14.02	*.98*	*.85*	13.95
M	14.27	.43	.51	14.40	13.53	.18	.69	13.45	15.02	*.80*	*.72*	14.85
N	14.46	.59	.76	14.60	14.64	.50	.39	14.48	15.27	.28	*.70*	15.08
O	14.46	.74	.76	14.65	15.31	——	.14	15.20	15.12	.19	.14	15.15
P	15 14	.67	.76	15.52	15.44	——	.37	15.39	15.51	.49	.14	15.38

	S Cassiopeiae				*R Ceti a*				*U Arietis*		
	1902 April 5	1902 June 6	1902 June 6	Mean Magn.	1901 Nov. 30	1902 Feb. 4	1902 Feb. 7	Mean Magn.	1902 Feb. 8	1902 March 25	Mean Magn.
Seeing Shade	*vg*	*f*	*f*		*vg* 0.84	*g*	*vg*		*p* 0.84	*g*	
Mo	9.79	10.41	9.90		10.78	9.74	9.73		9.44	9.59	
A	11.41	.57	.49	11.49	12.28	.33	.14	12.25	12.37	.69	12.53
B	11.72	.88	.80	11.80	12.51	.26	.42	12.40	13.03	*.84*	12.94
C	11.92	.44	.84	11.73	12.26	.22	.23	12.24	13.13	.12	13 12
D	11. *c*	72	82	11 77	12 50	72	81	12 68	13 15	26	13 20
E	12.14	24	*93*	12 10	13 04	07	01	13 04	13 50	28	13 39
L	13 74	.86	.68	13.76	14.61	.60	.26	14.49	14.48	.57	14.52
M	14.48	*.94*	*.77*	14.06	14.57	.70	.22	14.50	15.05	*..78*	14.92
N	14.49	.86	.13	14.49	14.80	.63	.32	14.58	15.15	*.87*	15.01
O	14.81	.74	.27	14.61	16.05	*.84*	*.50*	15.80	15.23	.05	15.14
P	15.04	*.92*	*.55*	14.84	15.96	.93	.63	15.84	15.32	.23	15.28

* Series of measures incomplete. Measures on faint stars given half weight.

a Measures by J. P. McCallie.

b Hagen 30 measured by mistake. Not used as standard.

c Hagen 50 measured by mistake.

McCormick Measures. Fifteenth Magnitude.

	R Persei				*V Tauri*				*S Orionis*				
	1901 Dec. 31	1902 Jan. 1	1902 March 3	Mean Magn.	1901 Dec. 3	1901 Dec. 5	1902 Jan. 4	Mean Magn.	1901 Oct. 22	1902 Jan. 6	1902 Jan. 13	1902 Feb. 7	Mean Magn.
Seeing	*p*	*g*	*g*		*p*	*vg*	*g*		*g*	*g*	*g*	*vg*	
Shade	0.84	0.84	0.84		0.84	1.70				0.84	0.84	0.86	
Mo	10.97	10.34	10.96		10.40	10.72	10.44		8.67	10.26	9.47	9.53	
A	11.18	.44	*.88*	11.17	——	——	——	*d*	12.01	*.81*	*.79*	*.90*	11.88
B	11.73	.60	.83	11.72	12.78	.80	.84	12.81	11.62	.78	.95	.68	11.76
C	11.84	.64	.64	11.71	12.07	.25	.33	12.22	11.54	.64	.63	.48	11.57
D	11.67	.74	.80	11.74	12.15	.09	.03	12.09	12 20	.10	.16	.07	12.12
E	11.61	.65	.90	11.72	12.81	.68	.61	12.70	11.79	.82	.66	.99	11.82
L	13 75	.85	.98	13.86	14.86	.47	.21	14 51	14.68	*.52*	.70	*.07*	14.94
M	14 08	.20	.29	14.19	14.84	.76	.13	14.58	14.41	*.48*	.88	*.19*	14.99
N	14 29	14	63	14 35	15.45	.27	.28	15.33	14 89	*.37*	.75	*.50*	15.08
O	14 40	11	63	14 38	15.45	.27	.53	15.42	14.87	*.64*	*.02*	*.25*	15.20
P	15 50	.66	——	15 58	15.62	.53	.45	15.53	15.00	.80	.17	.36	15.33

	V Aurigae				*R Geminorum*				*U Puppis*			
	1902 April 30	1902 May 1	1902 May 4	Mean Magn.	1902 Jan. 13	1902 Jan. 14	1902 Feb. 15		1902 April 10	1902 April 24	1902 April 27	Mean Magn.
Seeing	*vg*	*vg*	*vg*		*vg*	*g*	*vg*		*g*	*p*	*vg*	
Shade	0.84				0.84	0.86	0.86					
Mo	10.13	9.28	10.82		9.56	9.66	9.48		9.73	8.10	9 06	
A	11.79	.75	.59	11.71	11.74	.93	87	11.85	11.29	.59	46	11.45
B	12.30	.51	.26	12.36	11.56	.51	.63	11.57				*i*
C	12.70	.50	.20	12.47	12 26	.18	.18	12 21	11.59	.59	63	11.60
D	12.28	.58	.28	12.38	12.23	.20	.13	12.19	11.51	.40	.28	11 40
E	12.43	.16	*.18*	12.59	12.35	.47	.61	[12.48]*e*	11.29	.09	.29	11.22
L	14.62	.40	.25	14.42	13.70	.62	.68	13.67	14.11	*.82*	.05	13 99
M	14.89	.47	.56	14 64	14 33	01	.09	14 15	14.60	.00	.35	14 32
N	15.08	*.79*	03	14 97	14 82	67	.67	14 72	14.60	.06	61	14 42
O	15.14	*.76*	31	15 07	14 78	.65	.86	14 76	14.86	.01	.55	14 48
P	15.54	*.93*	18	15 32	15 16	02	18	15 12	14 67	.13	.83	14 54

d Hagen 4 measured.
e Star E is the variable Z Geminorum. Not used as standard.
i Hagen 82 measured by Professor E. C. Pickering.

McCormick Measures. Fifteenth Magnitude.

	V Cancri				*T Hydrae*				*R Leonis Minoris*			
	1902 April 11	1902 May 1	1902 May 4	Mean Magn.	1902 April 10	1902 April 30	1902 May 8	Mean Magn.	1902 April 10	1902 May 8	1902 May 28	Mean Magn.
Seeing Shade	*g*	*g*	*g* 0.84		*g*	*g*	*vg*		*p*	*vg*	*g*	
Mo	10.04	9.33	10.93		10.17	10.22	11.02		10.21	11.05	10.53	
A	11.66	.30	.42	11.46	11.54	.55	.62	11 57	12 36	.38	.52	12.42
B	11.56	.92	.77	11.75	12.01	.14	.03	12.06	12.56	.58	.54	12.56
C	12.22	.01	.28	12.17	12.28	.11	.10	12.17	13.33	.35	.21	13.30
D	12.50	.56	.45	12.50	12.17	.01	.15	12 12	12.95	.61	*.63*	12.86
E	12.31	.49	.32	12.37	11.93	*.04*	*.02*	12.00	13.08	.33	*.98*	13.13
L	14.19	.68	.61	14.59	15.11	.04	*.92*	15.02	15 32	*.94*	.18	15.15
M	14.24	.79	.83	14 62	15.31	.25	.19	15 25	15.31	.16	28	15.25
N	15.25	.09	.88	15 41	15 46	.42	.53	15 47	15 42	.60	85	15.62
O	15. —	.40	*.05*	15.72	15 33	.50	.62	15 48	15.56	.43	.89	15.62
P	15.70	.45	*.16*	15.77	15.81	.78	*.03*	15.87	15 65	.80	*.11*	15.85

	W Leonis				*T Virginis*				*T Ursae Majoris*			
	1902 April 10	1902 April 11	1902 April 12	Mean Magn.	1902 April 30	1902 May 1	1902 June 2	Mean Magn.	1902 May 1	1902 June 4	1902 June 4	Mean Magn.
Seeing Shade	*p*	*g*	*p*		*vg* 0.86	*g*	*g*		*g*	*g*	*g*	
Mo	10.18	9.98	10.67		10.45	8.88	11.05		10.44	10.77	10.33	
A	12.35	.38	.61	12.45	11.58	.34	.40	11.44	12.50	.70	.67	12.62
B	12.17	.24	.21	12.21	11.65	.23	.77	11.55	12.55	.31	.65	12.50
C	12.69	.64	*.02*	12.78	12.51	.62	.31	12.48	13.30	.43	.27	13.33
D	12.72	.70	.37	12.60	12.06	.41	.57	12.35	13.35	.28	.33	13.32
E	13.01	*.96*	*.70*	12.89	11.96	*.18*	.73	11.96	13.31	.29	.10	13.23
L	14.76	——	.56	14.66	13.80	.80	.82	13.81	14.64	.51	.38	14.51
M	15.17	*.86*	.41	15.15	14.67	.49	.34	14.50	15.13	.05	*.93*	15.01
N	15.44	*.90*	.48	15.27	14.76	.63	.77	14.72	15.76	.90	.51	15.72
O	15.42	*.98*	.55	15.32	14.92	.84	.85	14.87	15.95	.93	.68	15.85
P	15.62	.24	.87	15.58	15.55	——	.39	15.47	15.90	*.19*	.81	15.97

McCormick Measures. Fifteenth Magnitude.

	U Virginis				*S Virginis*				*S Bootis*			
	1902 May 29	1902 June 1	1902 June 2	Mean Magn.	1902 April 30	1902 May 8	1902 May 28	Mean Magn.	1902 June 1	1902 June 4	1902 June 5	Mean Magn.
Seeing	*vg*	*g*	*g*		*vg*	*g*	*g*		*g*	*g*	*g*	
Shade		0.84	0.84									
Mo	10.63	10.49	10.91		10.67	10.73	10.61		10.85	10.27	10.27	
A	11.54	.58	.44	11.52	12.15	.27	.21	12.21	12.33	.31	.21	12.28
B	11.46	.54	.51	11.50	12.15	.20	*.92*	12.09	12.47	.30	.42	12.40
C	11.93	*.17*	*.31*	12.14	12.11	.19	.25	12.18	12.85	.66	.72	12.74
D	12.67	.60	.52	12.60	12.84	.53	.95	12.77	12.61	.97	.84	12.81
E	12.85	.52	.64	12.67	12.97	*.00*	.87	12.95	12.75	.80	.81	12.79
L	14.76	.57	.35	14.56	14.87	.74	*.05*	14.89	14.66	.81	.76	14.74
M	15.43	*.66*	*.60*	14.90	15.30	——	.41	15.36	15.25	.30	.15	15.23
N	15 73	.43	.32	15.49	15.72	.51	.88	15.70	15.55	.28	.24	15 36
O	15.89	.69	.40	15.66	16.00	*.53*	*.89*	15.81	15.77	.42	.56	15.58
P	15 82	.84	.62	15.76	15.91	.61	.99	15.84	16.33	.01	.11	16.15

	R Camelopardalis				*R Serpentis*				*RR Librae* *a*			
	1902 June 1	1902 June 2	1902 June 4	Mean Magn.	1901 Aug.8	1901 Aug. 9	1902* June 5	Mean Magn.	1902 May 1	1902 May 29	1902 May 29	Mean Magn.
Seeing	*vg*	*vg*	*g*		*g*	*vg*	*f*		*g*	*vg*	*vg*	
Mo	10.90	11.48	10 57		10 34	9.21	10.61		9.96	10.81	10.66	
A	——	——	——	——*f*	11.47	.48	66	11.54	11.61	.56	.61	11.59
B	12 24	.19	.07	12.17	11.34	.49	.29	11.37	11 49	.67	.61	11.59
C	12 17	.18	.21	12.19	11.51	.68	.57	11.59	11.66	.63	.67	11 65
D	——	——	——	——*f*	11.96	.95	.92	11.94	11.73	.60	.69	11 67
E	12 79	.83	.93	12.85	12.40	.08	.23	12.24	11.56	.61	.45	11.54
L	14 09	*.74*	.26	14 03	14.32	.54	*.90*	14.32	14.16	.42	.39	14 32
M	14.73	.22	.62	14.52	15 06	.04	*.66*	14.97	14.41	.73	.64	14.59
N	15 58	*.87*	.30	15 25	15.12	.20	*.42*	15.01	14 73	*.26*	*.26*	15 08
O	15 73	51	.52	15.59	15 32	.16	.47	15 29	15.02	.53	.34	15 30
P	15 95	39	86	15 73	15.46	.45	*.76*	15 32	14.99	*.59*	*.60*	15 39

a Measures by J. P. McCallie.

f Wrong stars measured.

* Series of measures incomplete. Measures on faint stars given half weight.

McCormick Measures. Fifteenth Magnitude.

	R and S Scorpii				*W Herculis*				*R Draconis*				
	1902 April 30	1902 June 1	1902 June 2	Mean Magn.	1902 April 26	1902 June 4	1902 June 8	Mean Magn.	1902*a* June 5	1902 June 6	1902 June 7	1902* June 7	Mean Magn.
Seeing	*vg*	*vg*	*vg*		*p*	*vg*	*vg*		*g*	*g*	*f*	*f*	
Shade			0.84				0 84						
Mo	10.30	10.46	11.72		9.37	10.91	11.51		10.56	10.93	10.54	9.56	
A	11.51	.54	.63	11.56	11.48	.54	.62	11.55	11.55	.18	.50	.03	11.32
B	12.23	.18	.11	12 17	11.40	.77	.64	11.60	11 73	.80	.64	.79	11.74
C	12 04	.02	*.97*	12.01	11.55	.54	.40	11.50	12 18	.14	.40	.56	12.32
D	12.10	.23	.22	12.18	11 94	86	.78	11.86	12.53	.65	.42	.78	12.60
E	12.65	.54	.58	12.59	12.25	*.93*	.17	12.11	12 22	.43	.22	.03	12 22
L	14.38	.71	.48	14.52	13 92	.93	.69	13.85	14.37	.54	*.86*	*.64*	14.14
M	14.91	.59	.22	14.57	14.29	.23	.36	14.29	14.29	.42	.13	*.71*	14.18
N	14 83	.87	.91	14 87	15 01	.67	*.99*	15.22	14 05	.79	.43	*.81*	14.38
O	14 99	.91	.88	14 93	15 32	.60	14	15.35	14.55	*.51*	.79	*.97*	14.79
P	15.74	.76	.46	15 65	16.—	.41	*.82*	16 11	14 99	*.44*	*.14*	.52	15.11

	S Herculis				*R Aquilae*				*Z Sagittarii*			
	1902 June 5	1902 June 5	1902*a* June 5	Mean Magn.	1901 Aug. 8	1901 Aug. 9	1901 Aug. 20	Mean Magn.	1901* Sept. 1	1901* Nov. 7	1901 Nov. 8	Mean Magn.
Seeing	*g*	*g*	*vg*		*vg*	*vg*	*vg*		*g*	*g*	*vg*	
Mo	10.46	10.48	10.52		8.90	9 06	9.41		9.48	8.70	9 22	
A	11.27	.36	.44	11.36	11.47	.51	.55	11 51	10.48	.64	.48	10.53
B	11.47	.40	.32	11.40	11.61	.70	.73	11 68	11.13	*.87*	*.80*	10.93
C	11.54	.52	.66	11.57	11.61	.70	.73	11.70	10.88	.94	.94	10.92
D	11.74	.81	.76	11.77	12.04	*.77*	.72	11.84	11.54	.39	.56	11.50
E	11.98	.90	.80	11.89	11.12	.43	.30	[11.28]*g*	11.42	.59	.66	11.56
L	14.24	.29	.33	14.29	14.60	.72	.50	14.61	14.54	*.73*	.13	14.13
M	14.39	.28	.25	14.31	14.67	.78	.74	14.73	14.40	*.89*	.14	14.14
N	14.57	.47	.01	14 35	14 89	.90	.83	14.87	14.48	*.85*	.12	14.15
O	14.95	*.11*	.51	14 86	14 73	.93	.97	14.88	14.78	.30	.19	14 42
P	15.58	.28	*.95*	15.27	14 85	*.24*	*05*	15 05	14 84	.21	.51	14.52

* Series of measures incomplete. Measures on faint stars given half weight.

a Measures by J. P. McCallie.

g Hagen 20 measured. Not used as standard.

McCormick Measures. Fifteenth Magnitude.

	χ *Cygni* [a]				*R Vulpeculae*				*V Capricorni*			
	1901 Oct. 3	1901 Oct. 5	1901 Oct. 7	Mean Magn.	1901 Nov. 28	1901 Nov. 30	1901 Dec. 7	Mean Magn.	1901 Oct. 5	1901 Oct. 6	1901 Oct. 7	Mean Magn.
Seeing	*vg*	*vg*	*g*		*g*	*vg*	*g*		*g*	*f*	*g*	
Shade					0.84	0.84	0.84					
Mo	10.22	9.57	9.51		9.92	9.84	9.48		9.74	8.96	9.68	
A	10.77	.80	.46	10.68	10.61	.58	.61	10.60	10.73	.85	.80	10.79
B	11.55	.19	.22	11.32	10.38	.41	.53	10.44	11.26	.16	.24	11.22
C	10.98	*.01*	.78	10.92	10.78	.74	.63	10.72	11.20	.16	.15	11.17
D	11.17	.33	.68	11.39	11.00	.01	*.98*	11.00	11.28	.41	.30	11.33
E	11.09	.21	.40	11.23	11.14	.00	*.83*	[10.99]*h*	11.38	.23	.34	11.32
L	13.14	.35	.10	13.20	13.93	*.12*	.63	13.89	13.96	*.03*	.76	13.92
M	13.64	.74	.43	13.60	14.09	.12	.08	14.10	14.09	.23	.62	14.31
N	13.45	——	——	13.45	14.45	.18	.26	14.30	14.91	.77	.57	14.75
O	14.45	.87	.31	14.54	14.94	.82	.28	14.68	15.07	*.76*	*.58*	14.80
P	14.59	.85	.84	14.76	15.21	*.82*	*.44*	14.82	15.89	.32	.58	15.60

	R Lacertae				*S Aquarii*				*R Pegasi*			
	1901 Oct. 3	1901 Oct. 5	1901 Oct. 7	Mean Magn.	1901 Oct. 9	1901 Oct. 10	1901 Oct. 15	Mean Magn.	1901 Oct. 8	1901 Oct. 16	1901 Oct. 18	Mean Magn.
Seeing	*vg*	*vg*	*g*		*vg*	*vg*	*f*		*f*	*g*	*vg*	
Mo	10.82	9.91	10.26		9.69	9.08	10.06		8.93	9.23	9.51	
A	12.08	*.68*	*.57*	11.78	11.04	.16	.06	11.09	11.76	.72	.73	11.74
B	12.16	.28	.45	12.30	11.25	.27	.29	11.27	12.18	.18	.07	12.14
C	12.30	.30	.50	12.37	11.77	.74	.84	11.78	12.05	*.93*	*.86*	11.95
D	12.46	.71	.58	12.58	11.86	.71	.78	11.78	11.92	.70	.68	11.77
E	12.41	.45	.32	12.39	11.89	.94	.84	11.89	11.76	*.17*	*.35*	12.09
L	13.70	*.20*	.74	13.88	13.74	.81	.40	13.65	14.04	.06	.12	14.07
M	14.80	*.07*	.16	14.68	14.55	.36	.28	14.40	14.14	.81	.89	14.61
N	14.96	*.05*	.36	14.79	14.86	.70	.78	14.78	14.82	.84	*.09*	14.92
O	14.79	*.31*	.73	14.94	15.03	*.76*	*.98*	14.92	14.98	——	.98	14.98
P	15.90	*.01*	.59	15.83	15.26	*.99*	.03	15.09	15.05	.19	.41	15.22

a Measures by J. P. McCallie.
h Hagen 28 measured. Not used as standard.

TABLE X.

McCormick Measures. Fourteenth to Sixteenth Magnitude.

	U Cassiopeiae					*S Piscium*					*S Cassiopeiae*				
Obs.	1920 Dec. 16 A	M	1922 Jan. 31 A	M	Mean Magn.	1920 Jan. 18 A	M	1921 Nov. 22 A	M	Mean Magn.	1921 Jan. 3 A	M	1921 Jan. 4 A	M	Mean Magn.
Mo	9.60	9.79	10.08	9.88		10.45	10.69	10.37	10.37		9.45	9.38	9.42	9.42	
A	12.16	.05	.18	.17	12.14	11.35	.22	.32	.34	11.31	11.17	.13	*.97*	.27	11.14
B	11.45	.64	.51	.45	11.51	11.76	.95	.42	.43	11.64	11.68	.88	.75	.64	11.74
C	12.17	.14	.17	.23	12.18	11.79	.65	.91	*.13*	11 87	11.83	.82	.80	.48	11.73
D	12.16	*.96*	.18	.20	12.12	11.88	.92	.92	.60	11.83	11.72	.87	.86	.77	11.80
E	12 37	.50	.28	.26	12.35	12.25	.27	.40	.43	12.34	12.46	.16	.44	.66	12.44
F	13.15	.48	.16	.28	13.27	13.21	.56	.26	*.94*	13.24	13.65	.73	.72	*.09*	13.80
G	13 52	.64	.60	.37	13.53	13.98	*.21*	.63	.78	13.90	13.78	.62	.85	.57	13 70
H	13.62	.79	.57	.54	13.63	14.37	.50	.21	*.94*	14.26	13.95	*.08*	.87	.93	13.96
J	13.69	.73	.81	.55	13.70	14 48	.64	*.95*	*.62*	14.17	13.85	.97	.85	.84	13.88
K	14.73	.79	.64	.52	14.67	14.68	.34	.23	*.84*	14.27	14.36	.49	.27	.19	14.33
L	13.58	64	.43	.40	13.51	13.98	*.21*	.63	.78	13.90	13.86	.88	.76	.66	13.79
M	13.69	.73	.81	.55	13.70	14.92	*.04*	*.86*	*.42*	14.31	14.17	.03	.07	*.61*	13 97
N	14.61	.90	.44	.40	14.59	15.14	*.88*	*.56*	*.61*	14 80	14.42	.43	.18	.32	14 34
O	15.79	*.09*	.53	.26	15.67	15.44	.46	*.82*	*.83*	15.14	14.84	.73	.78	.72	14 77
P	15.56	.62	.54	*.80*	15.38	15.68	.21	*.97*	*.64*	15 12	15.05	.17	.09	*.96*	15.07
Q	14.79	*.05*	.83	.86	14.88	15.08	.14	*.79*	*.61*	14.90	15.26	.15	.25	.11	15.19
R	15.41	.91	.11	.03	15.37	15 38	.48	.10	.16	15.28	15.64	.37	.07	*.91*	15 25
S	15.25	.34	.31	.15	15.26	15.52	.11	.20	*.68*	15.13	15.36	.24	.33	.21	15.28
T	15.64	.33	.46	.33	15.44	16.04	*.72*	*.54*	*.62*	15.73	15.34	.05	.26	.25	15.22
U	15.15	.21	.31	——	15.22	15 90	.71	.98	.66	15 81	——	——	——	——	——

	U Arietis					*R Persei*					*V Tauri*				
Obs.	1920 Oct. 19 A	M	1920 Dec. 16 A	M	Mean Magn.	1920 Mar. 9 A	M	1920 Mar. 21 A	M	Mean Magn.	1921 Jan. 3 A	M	1921 Jan. 6 A	M	Mean Magn.
Mo	10.65	10.42	9.90	9.93		9.59	9.49	9.54	9.74		9.52	9.58	9.48	9.45	
A	12.45	.32	.43	.55	12.44	10.88	*.08*	.89	*.05*	10.98	12.75	.67	.46	.45	12 58
B	13.08	*.97*	*.98*	*.95*	13.00	11.86	.71	.78	.78	11.78	——	——	——	——	*k*
C	13 24	.05	.22	.16	13.17	11.47	.76	.69	.72	11.66	12.39	.26	.43	.37	12.36
D	13.18	.43	.20	.25	13.26	11.71	.64	.72	.47	11.64	12.18	.25	.37	.45	12.31
E	13.24	.40	.32	.28	13.31	12.15	*.86*	*.99*	.02	12.00	12.41	.52	.44	.45	12.46
F	14.14	.14	*.85*	*.83*	13.99	13.67	.90	.51	.45	13.63	13.66	.67	.80	.72	13.71
G	14.03	*.78*	.09	.10	14.00	14.13	*.81*	.03	.19	14.04	14 08	*.91*	.21	.02	14.06
H	14.27	*.91*	.03	.00	14.05	13.97	*.02*	.95	*.00*	13.98	14.15	*.94*	*.91*	*.65*	13.91
J	14.12	*.83*	.51	.22	14.17	13.84	.96	*.09*	.96	13.96	14 06	.28	.13	.00	14.12
K	14.86	.56	.73	.73	14.72	14.28	.28	*.96*	.07	14.15	——	——	——	——	*k*
L	14.60	.42	.85	.88	14.69	14.37	.18	.31	.33	14.30	14.90	.73	.47	.25	14.59
M	15.08	*.64*	.20	.27	15.05	14.44	.20	.60	.01	14.31	14.79	.95	.77	.79	14.82
N	15.35	*.88*	.11	.28	15.15	14.78	.79	.74	.45	14 69	15.08	.29	*.94*	*.90*	15.05
O	15.62	.59	.91	*.02*	15.78	14.78	.66	.76	.93	14.78	15.41	.32	.36	*.82*	15.23
P	15.48	.47	.65	.45	15.51	15.61	*.94*	.38	.33	15.32	15.52	.31	.11	.12	15.26
Q	15.06	.03	*.94*	*.87*	14 98	15.16	*.97*	.25	.18	15.14	15.41	.32	.36	*.82*	15.23
R	15.64	.35	.70	.72	15.60	15.20	.04	.72	.16	15 28	15 08	.29	*.94*	*.90*	15.05
S	15.78	.66	.50	.62	15.64	——	——	——	——	——	14 79	.95	.77	.79	14.82
T	15.06	*.82*	*.97*	*.91*	14.94	——	——	——	——	——	15 57	.36	.46	.88	15.57
U	15.44	.19	.44	.24	15.33	——	——	——	——	——	15.52	.31	.11	.12	15.26

k Stars B and K are double.

McCormick Measures. Fourteenth to Sixteenth Magnitude.

	V Aurigae					*R Geminorum*					*V Cancri*				
Obs.	1919 Dec. 21-22 A	M	1922 Jan. 31 A	M	Mean Magn.	1921 Jan. 4 A	M	1922 Jan. 31 A	M	Mean Magn.	1921 Feb. 3 A	M	1921 Feb. 6 A	M	Mean Magn.
Mo	10 82	10 80	10.69	10.29		9.04	8.94	10.34	10.20		10.16	9.99	9.99	9.91	
A	11.76	.82	.84	.75	11.79	12.20	.01	*.95*	.13	12.07	11.56	.63	.58	.56	11.58
B	12.52	.50	.35	.43	12.45	11.50	.78	.53	.61	11.60	11.32	.64	.69	.55	11.55
C	12.17	.20	.35	.35	12.27	12.17	*.95*	.28	*.91*	12.08	12.11	.08	.07	.05	12.08
D	12.41	.32	.29	.16	12.30	11.91	*.07*	*.04*	*.16*	12.04	12.64	.52	.47	.61	12.56
E	12.63	.67	.64	.79	12.68	——	——	——	——	*e*	12.62	.39	.50	.50	12.50
F	13.53	.36	.42	.39	13.42	13.16	.20	.13	.35	13.18	13.47	.54	.43	.22	13.42
G	13.—	——	.69	.71	13.70	12.85	*.03*	*.02*	.95	12.96	13.56	.68	.48	.28	13.50
H	13.98	.98	.98	.74	13.92	13.16	*.94*	*.95*	*.99*	13.01	13.58	.53	.76	.46	13.58
J	13.82	.82	*.08*	.93	13.92	13.36	.11	.16	.56	13.30	13.81	.58	.75	.49	13.66
K	14.—	——	.03	.07	14.05	14.18	.21	.28	.71	14.34	13.90	.58	.84	.62	13.74
L	14.90	*.19*	.77	.48	14.84	13.36	.47	.71	.83	13.59	14.79	.68	.76	.97	14.80
M	15.06	.18	*.78*	*.38*	14.85	13.99	.76	*.15*	.97	13.97	14.91	.92	.57	.64	14.76
N	15.64	.72	.59	.47	15.60	14.42	.35	.98	*.03*	14.70	15.79	*.07*	.60	.73	15.80
O	15.89	.98	.75	.52	15.78	14.53	.64	*.08*	*.07*	14.83	15.80	.87	.79	.89	15.84
P	16.—	——	.07	*.55*	15.81	15.06	.11	.72	.61	15.38	——	——	——	——	——
Q	14.52	.74	.68	.43	14.59	14.97	*.10*	*.37*	*.20*	15.16	15.01	*.94*	*.84*	.02	14.95
R	15.07	*.84*	*.79*	*.53*	14.81	15.19	*.97*	.57	.02	15.19	15.48	.53	.44	.55	15.50
S	15.34	.42	.19	.16	15.28	15.—	——	.60	.62	15.61	15.01	*.66*	.20	.01	14.97
T	15.30	.34	*.76*	*.40*	14.95	15.—	——	.61	.18	15.40	16.14	.06	——	——	16 10
U	15.73	.72	.55	.03	15.51	15.08	*.73*	.42	.22	15.11	16.12	.38	.03	.16	16.17

	R Leonis Minoris					*W Leonis*					*T Ursae Majoris*				
Obs.	1921 April 4 A	M	1921 April 5 A	M	Mean Magn.	1921 Feb. 3 A	M	1921 Feb. 6 A	M	Mean Magn.	1921 Mar. 11 A	M	1921 Mar. 29 A	M	Mean Magn.
Mo	10.27	9.99	10.62	10.32		10.19	10.09	9.63	9.80		10.08	10.06	10.20	9.78	
A	12.26	.36	.20	.17	12.25	12.28	.44	.16	.20	12.27	12.65	.67	.63	.67	12.66
B	12.70	.62	.72	.61	12.66	12.18	.36	.29	.30	12.28	12.64	.56	.64	.74	12.64
C	13.31	.29	.13	.24	13.24	12.55	.51	.52	.48	12.52	13.14	.22	.32	.45	13.28
D	12.86	.78	.98	.95	12.89	12.83	.62	.74	.72	12.73	13.31	.37	.24	.01	13.23
E	13.16	.22	.23	.32	13 23	13.10	.01	.21	.22	13.14	13.26	.16	.19	.11	13.18
F	13.45	.56	.41	.37	13.45	14.09	.11	*.94*	.20	14.08	13.72	.67	.52	.32	13.56
G	13.41	.80	.54	.62	13.59	14.14	.17	.62	.31	14.31	13.96	.84	.69	.31	13.70
H	13.81	.95	.64	.57	13.74	14.22	.18	.21	.49	14.28	14.25	.14	.19	*.98*	14.14
J	14.68	.56	.84	.69	14.69	14.51	.49	.51	.82	14.58	14.75	.51	.70	.40	14.59
K	14 80	.49	.68	.61	14.64	14.51	.62	.50	.62	14.56	15.03	.10	*.82*	*.87*	14.83
L	15.31	.08	.35	.31	15.26	14.87	.89	.74	*.02*	14.88	14.97	.77	.63	.33	14.68
M	15.32	.30	.34	.43	15.35	15.54	.58	.46	.87	15.61	15.23	.20	*.99*	*.57*	15.00
N	15.84	.56	.92	*.14*	15.86	15.59	.54	.62	*.15*	15.72	15.93	.97	.73	.51	15.78
O	15.88	.64	.83	*.31*	15.92	15.52	.55	.57	.90	15.64	15.91	.61	.83	.62	15.74
P	16.08	*.98*	.27	.35	16.17	15.86	*.09*	.84	*.23*	16.00	15.98	.89	*.01*	.61	15.87
Q	14.63	.58	.52	.37	14.52	15.65	*.25*	.73	*.29*	15.98	15.62	.69	.54	.29	15.54
R	14.94	.85	.39	.62	14.70	15.46	.98	.71	*.21*	15.84	15.17	.46	.14	*.84*	15.15
S	15.31	.08	.35	.31	15.26	15.81	*.26*	.80	*.14*	16.00	15.23	.20	*.99*	*.57*	15.00
T	15.32	.22	.27	.25	15.26	——	——	——	——	——	15.95	*.06*	.73	.63	15.84
U	15.32	.30	.34	.43	15.35	15.69	.97	.60	*.14*	15.85	15.96	*.05*	*.11*	*.03*	16.04

e Star E is the variable Z Geminorum. Not used as standard.

McCormick Measures. Fourteenth to Sixteenth Magnitude.

	U Virginis					*S Bootis*				
Obs.	1921 March 11 A	M	1921 March 29 A	M	Mean Magn.	1921 April 4 A	M	1921 April 5 A	M	Mean Magn.
Mo	10.79	10.79	10.19	9.92		10.38	10.16	10.43	10.07	
A	11.29	.31	.01	.15	11.19	12.16	.06	.09	*.75*	12.02
B	11.50	.47	.34	.37	11.42	12.37	.42	.46	.52	12.44
C	12.22	.15	.18	.01	12.14	12.82	.69	.82	.94	12.82
D	12.52	.66	.78	.81	12.69	12.93	.97	.79	.94	12.91
E	12.89	.86	*.13*	*.10*	13.00	12.73	.88	.86	.91	12.84
F	13.51	.37	.57	.57	13.50	13.90	.73	.68	.62	13.73
G	13.53	.40	.53	.71	13.54	13.91	*.03*	.65	.61	13.80
H	13.66	.60	.94	.68	13.72	13.75	.69	.66	.54	13.66
J	14.09	*.94*	.40	.29	14.18	14.18	*.94*	.13	*.95*	14.05
K	14.11	.02	.14	.23	14.12	14.61	.43	.29	.16	14.37
L	14.82	.84	.65	.56	14.72	14.85	.58	.16	.96	14.89
M	15.41	.06	.16	.03	15.16	15.07	*.79*	.50	.25	15.15
N	15.64	.68	.65	.51	15.62	15.68	.47	.45	.46	15.52
O	15.92	.68	.86	.85	15.83	15.55	.34	.75	.62	15.56
P	15.76	.74	.56	.24	15.58	15.89	.51	*.35*	*.01*	15.94
Q	14.88	.87	.80	.60	14.79	15.03	*.94*	.21	.18	15.09
R	15.64	.68	.65	.51	15.62	14.85	.58	*.16*	.96	14.89
S	15.41	.06	.16	.03	15.16	15.07	*.79*	.50	.25	15.15
T	15.76	.74	.56	.24	15.58	15.68	.47	.45	.46	15.52
U	15.92	.68	.86	.85	15.83	15.55	.34	.75	.62	15.56

	R Serpentis					*W Herculis*					*S Herculis*				
Obs.	1921 May 8 A	M	1921 May 9 A	M	Mean Magn.	1921 Oct. 1 A	M	1921 Oct. 5 A	M	Mean Magn.	1921 June 5 A	M	1921 June 10 A	M	Mean Magn.
Mo	10.41	10.31	11.02	10.83		10.46	10.53	9.93	10.14		10.33	10.27	10.45	10.23	
A	11.28	.46	.59	.39	11.43	11.45	.34	.45	.57	11.45	11.33	.41	.34	.53	11.40
B	11.47	.43	.24	.36	11.38	11.59	.76	.72	.86	11.73	11.52	.67	.43	.49	11.53
C	11.51	.48	.62	.71	11.58	11.65	.53	.39	.48	11.51	11.40	.26	.43	.51	11.40
D	12.00	*.89*	*.99*	.06	11.98	11.96	.87	.94	.92	11.92	12.00	*.73*	.03	*.68*	11.86
E	12.44	.42	.27	.19	12.33	11.95	*.12*	*.12*	.87	12.02	11.76	.92	.76	.80	11.81
F	13.55	.20	.40	.42	13.39	13.66	.90	.72	.99	13.82	13.34	.42	.34	.39	13.37
G	13.82	.61	.71	.25	13.60	14.31	.36	.18	.52	14.34	13.27	.72	.35	.25	13.40
H	13.87	*.00*	*.03*	.76	13.92	14.19	.10	.07	.43	14.20	13.51	.62	.65	.57	13.59
J	14.19	.14	*.86*	*.41*	13.90	14.37	.00	.24	.43	14.26	14.17	.16	.48	.23	14.26
K	14.10	*.97*	.49	.17	14.18	14.32	.26	.34	.59	14.38	14.06	*.90*	.15	.06	14.04
L	14.38	.03	.07	*.70*	14.04	13.78	.78	.77	.79	13.78	14.63	.62	.46	.18	14.47
M	14.94	.75	.49	.20	14.60	14.07	.05	*.93*	.03	14.02	14.80	.89	.77	.75	14.80
N	14.94	*.05*	.77	.42	14.80	15.11	.32	*.93*	.27	15.16	14.83	.74	*.11*	.76	14.86
O	14.84	—	.43	.25	14.51	15.32	.16	.03	.39	15.22	15.42	.35	.45	*.99*	15.30
P	15.20	*.89*	*.68*	*.40*	14.79	16.07	.10	*.92*	*.83*	15.98	15.49	.66	.44	.25	15.46
Q	14.58	.37	.13	*.96*	14.26	15.40	.48	.28	.61	15.44	15.94	*.03*	.84	.45	15.82
R	14.94	.75	.49	.20	14.60	15.67	.79	.82	.91	15.80	15.91	.86	.91	.12	15.70
S	15.32	*.99*	.06	.02	15.10	16.18	*.65*	*.94*	*.83*	15.90	15.92	.96	.69	.41	15.74
T	15.71	.56	.47	.11	15.46	16.19	*.95*	*.97*	*.67*	15.94	16.13	.15	*.78*	*.98*	16.05
U	15.76	.67	.38	.14	15.49	——	——	——	——	——	15.28	.53	.60	*.91*	15.33

McCormick Measures. Fourteenth to Sixteenth Magnitude.

	R Aquilae					*χ Cygni*					*R Vulpeculae*				
Obs.	1921 June 10 A	1921 June 10 M	1921 Oct. 5 A	1921 Oct. 5 M	Mean Magn.	1920 Oct. 14 A	1920 Oct. 14 M	1920 Nov. 13 A	1920 Nov. 13 M	Mean Magn.	1920 Nov. 13 A	1920 Nov. 13 M	1920 Dec. 14 A	1920 Dec. 14 M	Mean Magn.
Mo	10.64	10.53	11.19	11.23		9.86	9.57	8.91	8.79		8.68	8.70	9.14	8.99	
A	11.48	.27	.59	.45	11.45	10.69	.77	.90	*.14*	10.88	10.60	.60	.54	.72	10.62
B	11.95	.98	.75	.84	11.88	10.95	*.21*	*.01*	.93	11.02	10.76	.93	.59	.60	10.72
C	11.80	.87	.84	.90	11.85	10.98	.84	*.11*	.93	10.96	10.53	.60	.58	.71	10.60
D	11.76	.73	.77	.68	11.74	11.50	.33	.32	.27	11.36	10.87	.63	*.03*	.73	10.82
E	11.92	*.05*	.93	*.05*	11.99	11.44	.40	.22	.27	11.33	——	——	——	——	*l*
F	13.04	*.80*	*.98*	*.81*	12.91	12.24	.23	.50	.61	12.40	12.76	*.07*	.75	.74	12.83
G	13.12	*.80*	.24	*.96*	13.03	12.63	.20	.66	.79	12 57	12 63	.77	.55	.89	12.71
H	13 08	.14	21	.16	13 15	12 55	.51	.88	.88	12.70	12.82	*.54*	.89	*.07*	13.03
J	14 18	*88*	*18*	*.46*	13.75	13 10	.26	.05	.16	13.14	13.13	.20	*.95*	.23	13.13
K	13.73	.38	.36	.47	13 48	13 44	.41	.32	.52	13.42	——	——	——	——	——
L	14.83	.43	.47	.28	14 50	13 33	.33	.21	.36	13.31	14.06	08	.01	.05	14.05
M	11.40	.36	.25	.12	14.28	13 56	.54	.48	.68	13.56	14.55	——	.14	.42	14.37
N	14.50	.58	.54	.51	14 53	13 50	.45	.62	.47	13.51	14 83	*.09*	*.33*	.76	14.98
O	15 04	*.72*	*92*	.10	14 94	14 60	.74	.40	.20	14.48	14.92	*.16*	*.02*	.96	15.02
P	15 16	*.99*	.01	.89	15 01	14 71	78	.55	.68	14 68	14.79	.78	*.16*	.90	14.91
Q	15.66	.61	.73	.94	15.74	14 63	.86	.52	.64	14.66	14.70	*.12*	.92	——	14.91
R	15 53	.22	.89	.61	15.56	14.71	.78	.55	.68	14.68	14.92	*.16*	*.02*	.96	15.02
S	16 —	——	.05	.12	16 08	15 59	.26	.20	.14	15.30	15.—	— -	.32	*68*	15.00
T	16.—	——	.35	.44	16.39	15.08	*.89*	.02	*.91*	14.98	15.—	——	.37	.20	15.28
U	16 —	——	.24	*.80*	16.02	15.69	.80	.18	.22	15.47	14.79	.78	*.16*	.90	14.91

	R Lacertae					*R Pegasi*				
Obs.	1920 Nov. 13 A	1920 Nov. 13 M	1921 Jan. 3 A	1921 Jan. 3 M	Mean Magn.	1921 Sept. 28 A	1921 Sept. 28 M	1921 Oct. 1 A	1921 Oct. 1 M	Mean Magn.
Mo	8 80	8.36	9.31	9.16		9 84	9 52	10 27	10 22	
A	11 81	.87	.69	.75	11.78	11.63	.70	.64	.59	11.64
B	12 42	.50	.30	.30	12 38	11.83	.81	.93	.74	11.83
C	12 41	.26	.35	.53	12.39	11.89	.71	*.00*	.98	11.90
D	12 54	.38	.63	.61	12.54	12 11	*.93*	*.85*	*.87*	11.94
E	12 24	.38	.44	.21	12 32	12 20	.53	.25	.49	12 37
F	13 12	.16	.19	.40	13 22	14 01	*.89*	.06	*.98*	13.98
G	13 12	.24	.35	.51	13 30	13 92	.52	.86	.77	13.77
H	13 41	.22	40	45	13 37	14 20	*.76*	*.74*	*.89*	13 90
J	13 53	.25	.66	.38	13 46	13 69	.37	.82	*01*	13 22
K	13 53	.42	.54	.80	13 57	13 98	.76	*.13*	*00*	13 97
L	13 95	59	*.10*	*.11*	13 94	14 34	33	.17	00	14 21
M	14 17	*91*	.56	.42	14 34	14 51	*71*	.33	53	14 27
N	14 10	*52*	34	.15	14 04	15 23	*69*	.16	24	15 08
O	14 52	64	66	.87	14 67	15 38	*.94*	.25	.24	15.20
P	15 16	*.91*	33	.03	15 11	15 23	.01	.50	.26	15.25
Q	14 43	11	80	.63	14 57	15 17	*.85*	.19	.33	15.14
R	14 63	21	92	.61	14.59	15 78	01	.72	.43	15 48
S	15 07	*89*	.29	.55	15 20	15 86	.17	.89	.42	15 58
T	14 95	68	*25*	*.43*	15 07	15.72	*80*	.59	47	15 40
U	——	——	——	——	——	15 56	.17	.92	.81	15 62

l Star E is double.

The Conditions to Insure Accuracy.

The discussion of the magnitudes resulting from this present Rumford work forces one to the conclusion that the wedge photometer is quite as accurate a form of instrument as the best of the polarizing photometers, provided, however, that sufficient precautions are taken. What precautions are necessary will be developed in the following pages.

The method followed by Professor E. S. King in making the photographic wedges is fully described in *Harvard Annals*, **41**, 237. "In making the wedges, plates 8 × 10 inches in size were used, so that the five wedges could be cut from a single plate. When, however, the plates were cut into strips, considerable breakage occurred, and finally more than one plate was used. Each photometer was next provided with one of these photographic wedges mounted on a strip of plain glass which was placed in contact with the film, and held in position with beeswax at the edges."

Wedge III was used in photometer III at the Lick Observatory. Wedge II was first sent to the Yerkes Observatory, but was later returned and was used by Professor S. I. Bailey in South America in the measurement of stars south of the equator. Photometer I is at the Leander McCormick Observatory. Although there is no record of the number of the wedge used, there are many reasons for believing that wedge I is the McCormick wedge. The fourth photometer was sent to the Princeton Observatory where the stars of fifteenth magnitude were to be measured. Wedge V was used by Parkhurst.

From the form of the calibration curve of the Lick wedge III, and from the comparison of the measures in *Harvard Annals*, **41**, 239 and 240, it seems certain that wedge III was cut from a different photographic plate from the other four wedges.

An attempt was made by King to have the absorption of the wedge increase by a constant amount with increase of the scale readings. Apparently this desirable constant was very nearly attained. Unfortunately in the early days of the use of the wedge photometer most of the observers seem to have entirely forgotten that the human eye is a very important part of the optical train, in fact, perhaps the most important part. Consequently, even though a uniform wedge had been constructed, with a constant increase of absorption with increase of scale, the effect produced on the eye of the observer need not be one of a constant ratio. In making a measurement of the brightness of a star there are superimposed on the absorption of the wedge any peculiarities of the eye, so that the measure is a combination of wedge absorption and eye estimation. It may be well to call attention to the fact that the statements made herewith refer not only to the photographic wedge, but with equal force to the wedge of neutral tinted glass. Any one who uses a "constant" for his wedge, whether this wedge is photographic or made of shade glass, is

neglecting a fundamental factor, the effect produced on the eye. Consequently, a thorough discussion of the calibration of the wedge is all important in the determination of stellar magnitudes, and since the effects on different eyes vary considerably, the calibration should in all cases be carried out by the observer who uses the wedge, for a calibration which fits the eye of one individual need not necessarily fit the eye of a different observer.

The observation with the wedge photometer is very simple, consisting as it does of matching the real star by means of an artificial star placed close along side of it. When the match in brightness is exact, the scale reading of the wedge is made. The observation is essentially the same, therefore, as that employed by one who observes variable stars visually by the Argelander method. If the real and artificial stars exactly match each other in appearance and if they are close together in position, the estimation of zero grades of difference in intensity can be made with a high degree of precision depending on the experience and skill of the observer. Observers are much better able to detect slight differences in magnitude between two stars when these stars are faint, but not too faint to be well seen in the telescope, than when they are bright. For instance, with a twenty-six-inch telescope, it is much easier to detect a difference of a tenth of a magnitude when the stars are about the thirteenth magnitude than when they are of ninth magnitude. Manifestly therefore, the calibration curve of the wedge should take care not only of the absorption of the wedge itself, but also of the estimates of the eye in connecting differences in grades of intensity with differences of magnitudes of the stars observed. If we had a wedge, photographic or otherwise, with an absorption constantly increasing from one end of the wedge to the other, and if a graph were made of the change in absorption in stellar magnitudes plotted against scale readings of the wedge, this curve would be a straight line parallel to the abscissa axis. If this wedge were now placed in a photometer and as the result of measurements with the eye a curve were made precisely as for the wedge alone, this curve would depart radically from a straight line.

To find the connection between the estimates of the eye in grades and differences in stellar magnitudes, one has only to refer to Harvard Annals. Such a skilled observer as Father Hagen, for instance, made many thousands of estimations in grades before the magnitudes of the stars estimated were determined. If Hagen grades are plotted against differences of stellar magnitudes, it is seen that Hagen is much more skillful in detecting slight differences of magnitude in the fainter stars, since he puts in more grades in a given magnitude interval, than in the brighter stars in his telescope. In fact, a striking resemblance is found between such a curve and the curves of slopes of the calibration of the Yerkes, Lick and McCormick wedges.

Since, therefore, a knowledge of the calibration curve of the wedge is so fundamental,

the greatest of care should be exercised in its accurate determination. To secure the best results many precautions must be taken,[1] chief among which are the following:

(1) The real and artificial stars should resemble each other very closely. As a matter of fact it is only when real and artificial stars are indistinguishable from each other that results of the best quality can be obtained. Not only should the stars resemble each other in appearance but in color as well. An exact match between real and artificial stars is possible only under good conditions of seeing. Fair or poor seeing will give poor results.

(2) The stars to be compared should be always in the same relative position. Possibly the most uniform results will be obtained when the stars are close together. It is unnecessary to observe with the stars in different positions, such as to left and to right, since the calibration curve will take care of any individual peculiarities.

(3) Care should be taken that the photometer lamp illuminate as constantly as possible; there should be no other lamps in the circuit, there should be no sliding contacts, and the lamp should burn nearly at its specified candlepower.

(4) The photometer lamp should burn as constantly as possible from night to night so that the stellar magnitude corresponding to O on the scale, or Mo, should be as constant as possible. Likewise to keep Mo constant the aperture used for forming the artificial star should be kept unchanged. In brief, all of the adjustments of the photometer should be kept as constant as possible. In addition to those above, there should be no change in the distance from the photometer lamp to the aperture forming the artificial star, and little or no change in distance from ground glass to aperture.

(5) If it is essential to keep the adjustments of the photometer as unchanged as possible it is manifestly of prime importance that the wedge should be calibrated under conditions as nearly as possible identical with those when used at the telescope in measuring stars.

(6) Observations should be made under conditions of uniform transparency, freedom from cloud and haze, and absence of moon.

(7) Measures of a region should be carried through direct, and repeated immediately in the reverse order so as to eliminate any progressive changes in transparency or in the brightness of the artificial star, or in absorption due to change of altitude.

(8) The use of shade glasses is open to suspicion on account of the change in the contrast of the background. However, it is probably preferable to have a small uncertainty due to the use of a shade glass than the larger uncertainties caused by observing stars so bright that there are large personal errors, especially when the stars observed without shade

[1] *Parkhurst, Researches in Stellar Photometry*, page 3.

would be placed at the thin part of the wedge where the calibration is known with some uncertainty.

The above precautions are only those of common sense, and they are no more difficult to attain than in any other piece of accurate astronomical measurement. The only condition that limits the use of the photometer is that no attempt should be made to work on nights of poor seeing. As stated above, the wedge should be calibrated under conditions as nearly identical as possible with those under which it is used at the telescope, any radical changes from these conditions rendering the resulting stellar magnitudes open to suspicion.

If the adjustments of the photometer are the same in the laboratory calibration as when used at the telescope, the stellar magnitudes derived should be reliable and without systematic errors, provided the real and artificial stars are indistinguishable in appearance from each other. This condition can usually be satisfied with telescopes of small aperture 6, 8, or 10 inches. With average seeing it becomes increasingly difficult, as the aperture of the telescope is increased, to make real and artificial stars appear alike. With the twenty-six-inch telescope under good conditions, real and artificial stars resemble each other very closely for stars fainter than the eleventh magnitude. For stars brighter, the eye of the observer can detect that the image of the artificial star is an area and not a point, and that the distribution of illumination of the real and artificial stars is different. For fair or poor seeing, these differences become accentuated due to the increased size of the image of the real star. If now the size of the aperture making the artificial star is increased and the position of the ground glass is changed in order that real and artificial stars be made to resemble each other, the conditions of adjustment are changed and the magnitudes derived may be in error. Experiments have been made at the Leander McCormick Observatory by Mitchell and Alden using apertures of different sizes for forming the artificial star, and by altering the brightness of the photometer lamp. A change in either of these conditions alters the value of the stellar magnitude corresponding to zero on the photometric scale, the value Mo. If two stars were measured, a bright star of approximate magnitude 10.5 and a faint star of 14.5 magnitude, the difference in photometric scale readings between these two stars was a constant so long as Mo was kept constant, but varied with a change in Mo. Consequently if the readings of the scale were turned into stellar magnitudes by means of the calibration curve, the difference in magnitude between the two stars varied considerably with a change in the value of Mo. A large opening for artificial star, or a brighter lamp corresponded always to a smaller range in magnitude. To obtain a constant difference in magnitude between the bright and faint stars it would be necessary to use a different calibration curve for each value of Mo.

It is therefore readily apparent that the value of Mo must be kept approximately constant from night to night. Since the observations for forming the calibration curve, especially if made in the laboratory, are ordinarily made under conditions that simulate those of good seeing at the telescope, there is no need to fear, from night to night, differences of scales between bright and faint stars provided care is taken to keep the value of Mo approximately constant, and provided that the seeing is good. However, if an observer works under poor conditions of seeing and employs a larger size of opening to form the artificial star so that real and artificial star may look alike to the eye, then under these conditions the difference in magnitude between bright and faint stars will be too small. The effect with poor seeing at the telescope is to push both the photometric settings for bright and faint stars closer to the zero end of the scale, the change for the bright stars, however, being less than for the faint stars. The terms "bright" and "faint" are here used in a relative sense, for a star that would be "bright" in a forty-inch telescope might be quite "faint" in a telescope of an aperture of four inches. The above conclusions are quite in keeping with the idea that the human eye is more sensitive to smaller differences of magnitude when stars are faint than when stars are bright. One is inevitably forced to the conclusion that under poor conditions of seeing there is less difference of magnitude between bright and faint stars than under good conditions, or in other words that there is a difference in scale for visual observations with various qualities of seeing.

The above conclusions are those of Mitchell and Alden, the effects being those of personal equation depending on the accuracy with which real and artificial stars can be exactly matched in appearance in the telescope. For the faintest of the Rumford series the real and artificial stars so closely resembled each other that they were usually indistinguishable under all conditions of seeing when measures were taken. For the brightest stars of the series it was impossible to get an exact match except when the conditions were good or excellent. The personal equation rests, therefore, almost entirely on the inability to measure the brightest stars exactly. Since the bright stars determine the value of Mo, the personal equation will therefore affect the magnitudes of the faint stars of the series by an amount which is approximately constant and which is the personal equation in the determination of Mo, the magnitude corresponding to zero on the scale. However, there is nothing in the wedge photometer that would confine these conclusions to magnitudes determined by means of it alone. The same effects must be found whenever magnitudes are investigated by the human eye, whether the magnitudes are measured by a photometer, either of the wedge type or of polarizing prisms, or whether the magnitudes are estimated by the eye as in the Argelander method. This difference in scale between nights of good and poor seeing need not, however, be a cause of uncertainty in the

investigations of stellar magnitudes. All that is necessary is that astronomers should not observe on nights of poor seeing, for such nights not only cause a difference in scale of magnitudes but render the magnitudes unreliable as well, since the seeing usually varies continually when it is poor. Hence it is a fallacy to believe that reliable magnitudes may be determined when the seeing becomes too poor for other astronomical work.

In photometric work the human eye is one of the most important elements in the optical train. Not only do the eyes of various observers differ, but the eye of any one astronomer varies from night to night. The variations in the eye will show their effect in the magnitudes derived, but the percentage error will probably be no greater than is found by the double star observer in measuring the position angle and distance of the components of a double.

The magnitudes determined by the wedge photometer are subject to accidental errors and changes of scale for reasons herein set forth, but if the wedge photometer is used under good conditions of seeing with the instrument kept in constant adjustment, it is probable that the magnitudes derived have quite as high a degree of accuracy as those determined by a photometer of polarizing form.

It might not be out of place to point out that photography has not been able to rid stellar magnitudes of all of the errors into which they may fall, and that in both photographic and photovisual magnitudes there are still large errors of scale to be found, and large accidental errors for which there is no adequate explanation.

The value of the present series lies in the number of independent observers and the various sized telescopes which have contributed to the results.

Discussion of the Measures.

The effect of personal equations for different observers using the same telescope is found by referring to Table V giving the Lick measures. In addition to Aitken, observations were made by Curtis, Stebbins and Townley. Curtis had already had experience in measuring the Rumford series at the McCormick Observatory, while the other two were practically inexperienced with this form of photometer. Curtis made measures on ten different regions on ten nights, Townley on five regions on seven nights, while Stebbins measured on three regions on four nights. There were five faint stars in each region. For the ten separate regions, or fifty different stars, the average difference in the magnitudes of Aitken and Curtis was 0.13, the results of Curtis making the stars brighter. Townley was 0.32 magnitudes brighter than Aitken, and Stebbins 0.24 fainter, the values for the four observers being in order of brightness, Townley, Curtis, Aitken and Stebbins. These personal equations give systematic corrections which should probably be applied to the three other observers to reduce them to the system of Aitken. The effect is shown

in marked degree in the field of S Herculis which Aitken measured on one night and Stebbins on two. The average shows that Stebbins is 0.46 magnitudes fainter than Aitken. No corrections were made in the reductions of the Lick measures for these personal equations, and consequently their effects are found in the final magnitudes as accidental errors.

As has already been stated (p. 241) little confidence can be felt in the Lick scale. It is therefore somewhat surprising to find below that this scale departs the least from the mean scale.

At the beginning of the preparation of the present work for publication it was at once noticed that the most vital portion of the research was that of the *scale* of magnitudes. The various measures by different observers with different telescopes must represent a variety of scales. Can these different scales be brought into harmony? It was for the purpose of throwing some light on this question that Mitchell and Alden made their measures. The faintest stars in the twenty-four regions north of the equator had been measured by the great refractors at both Lick and Yerkes, and hence it was decided at the McCormick Observatory to concentrate on these northern regions. The scale of magnitudes adopted in the present work depends on the mean of the observations of the faintest stars of the sequence with the three telescopes, Yerkes, Lick and McCormick, and by the four observers, Parkhurst, Aitken, Mitchell and Alden. The measures of the stars of the fourteenth and of the fifteenth magnitudes by the McCormick telescope have been adjusted to fit this adopted scale. On the left side of Tables XI and XII, which give the summary of measures, are found the magnitudes as directly observed, while on the right are these magnitudes adjusted to fit the uniform scale. In these tables are given the magnitudes and positions of the twenty stars of the Rumford series from twelfth to sixteenth magnitude inclusive, and in Table XI the positions as well of all those stars in each of these regions for which photometric magnitudes have been determined either at Harvard or by Parkhurst. In the illustrations these additional stars are marked by their Hagen numbers, while the Rumford series are marked by the letters A to U.

The positions of the stars were determined at the Yerkes Observatory by Miss Harriet McW. Parsons from the measurement of the photographs made with the two-foot reflector. The image of the variable, which is near the optical axis of the telescope, is taken as the origin, and the coördinates $\Delta\alpha$ and $\Delta\delta$ are given. The negatives were oriented for 1900 by the meridian places of the stars from the Astronomische Gesellschaft catalogues reduced to that epoch. Miss Parsons measured all stars except those of fourteenth magnitude in the twenty-four northern regions. The positions of the latter were determined by Alden from measures of photographic prints having a scale 1 mm. $= 10''$.

In Table XI are given the twenty-four regions north of the equator, and in Table XII the twelve regions south of the celestial equator.

TABLE XI.

Northern Regions.

U Cassiopeiae $0^h\ 40^m\ 46^s + 47^\circ\ 42'.6$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
19		+1 5.5	+ 3 54													
20		−0 22.0	+ 5 58													
22		+0 15.6	+ 1 3													
25		+0 31.0	− 5 54													
54	A	+0 26.7	+ 4 48	12.24	12.18	12.25	12.07	12.21	12.14	12.18	12.18					
55	B	+0 3.5	+11 7	11.48	11.61	11.62	11.73	11.73	11.51	11.60	11.60					
58	C	+1 11.6	− 2 20	12.12	12.20	12.16	12.21	12.21	12.18	12.18	12.18					
60	D	+0 34.8	+ 2 49	12.07	12.20	12.07	12.03	12.00	12.12	12.08	12.08					
63	E	+0 14.6	− 3 7	12.40	12.12	12.22	12.26	12.15	12.35	12.25	12.25					
	F	+0 39.4	− 5 32				13.13		13.27	13.20	13.20			13.18		13.22
	G	+0 4.9	+ 4 36				13.43		13.53	13.48	13.48			13.49		13.46
	H	+0 42.0	− 2 56				13.45		13.63	13.54	13.54			13.51		13.56
	J=M	+0 32.2	− 1 42				13.50	13.45	13.70	13.55	13.53			13.56	13.41	13.63
	K	+0 53.7	− 4 31				[13.70]*		14.67	14.67	14.55			[13.76]		14.55
	L	+0 49.5	+ 8 25					13.34	13.51	13.42	13.37				13.30	13.44
	M=J	+0 32.2	− 1 42				13.50	13.45	13.70	13.55	13.53			13.56	13.41	13.63
	N	+0 35.3	+ 3 30					14.48	14.59	14.54	14.44				14.41	14.47
	O	+0 59.3	+ 1 20					15.20	15.67	15.44	15.31				15.11	15.51
	P	+1 7.5	− 2 12					15.39	15.38	15.38	15.26				15.30	15.23
	Q	+0 38.2	− 2 12		14.38	14.75			14.88	14.67	14.67	14.55	14.70			14.75
	R	+0 28.0	− 2 30		14.88	15.16			15.37	15.14	15.14	15.09	15.10			15.22
	S	+0 43.4	− 4 52		15.01	15.25			15.26	15.17	15.17	15.22	15.19			15.11
	T	+0 48.4	− 5 18		14.99	15.24			15.44	15.22	15.22	15.20	15.18			15.28
	U	+0 43.7	− 6 13		14.98	15.17			15.22	15.12	15.13	15.19	15.11			15.08

S Piscium $1^h\ 12^m\ 21^s + 8^\circ\ 24'.3$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
8		+0 39.0	− 0 3													
9		+0 29.4	+ 7 38													
10		−0 54.3	+ 7 41													
12	A	+0 28.8	−12 14	11.22	11.33	11.34	11.42	11.23	11.31	11.31	11.31					
13	B	−1 13.4	− 4 45	11.59	11.69	11.56	11.66	11.59	11.64	11.62	11.62					
14	C	+0 50.2	+ 5 26	11.75	11.76	11.78	11.94	11.88	11.77	11.83	11.83					
15	D	+0 14.4	− 1 55	11.96	11.86	11.84	11.84	——	11.83	11.87	11.87					
16	E	+0 57.8	+11 51	12.50	12.37	——	12.17	12.37	12.34	12.35	12.35					
	F	+0 31.9	− 9 1				13.28		13.24	13.26	13.26			13.34		13.17
	G=L	+0 9.8	−10 19				13.65	13.95	13.90	13.82	13.81			13.73	13.89	13.80
	H	−0 12.5	− 8 53				13.87		14.26	14.06	14.06			13.98		14.15
	J	−0 14.8	+ 3 28				13.96		14.17	14.06	14.06			14.05		14.06
	K*	+0 14.1	− 5 23				14.21		14.27	14.24	14.24			14.31		14.16
	L=G	+0 9.8	−10 19				13.65	13.95	13.90	13.82	13.81			13.73	13.89	13.80
	M	−0 21.8	−12 47					14.85	14.31	14.58	14.48				14.76	14.20
	N	+0 8.5	− 9 35					15.08	14.80	14.94	14.82				14.98	14.66
	O	−1 6.0	− 2 35					15.15	15.14	15.14	15.02				15.05	14.99
	P	−0 4.0	−12 50					15.38	15.12	15.25	15.12				15.28	14.97
	Q	+0 22.5	+ 5 21		14.46	14.74			14.90	14.70	14.70	14.65	14.69			14.76
	R	+0 28.3	+ 2 38		14.71	14.97			15.28	14.99	14.98	14.92	14.91			15.12
	S	+0 27.6	+ 4 38		14.72	15.18			15.13	15.01	15.01	14.93	15.12			14.98
	T	+0 52.5	+ 4 16		15.26	15.48			15.73	15.49	15.49	15.51	15.41			15.55
	U	+0 49.6	+ 2 27		15.70	15.78			15.81	15.76	15.77	15.98	15.71			15.63

* Star K measured at McCormick (A) is 5′ N of star designated on photograph.

Northern Regions.

S Cassiopeiae $1^h\ 12^m\ 18^s + 72°\ 5'.1$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
9		−2 40.5	−10 35													
10		+0 52.3	−13 22													
11		+0 21.7	− 2 46													
12		−0 43.5	+ 7 20													
20	A	+3 8.7	+ 7 32	11.46	11.42	11.47	11 60	11.49	11.14	11.43	11 43					
22	B	+1 6.5	+13 47	11.64	11.66	11.63	11.60	11.80	11.74	11.68	11.68					
25	C	+2 2.2	+11 31	11.65	11.79	11 63	11.58	11.73	11.73	11 68	11 68					
27	D	+0 42.8	− 7 34	11.67	11.88	11.81	11.81	11.77	11.80	11.79	11.79					
35	E	−0 4.3	− 4 33	12.44	12.13	12.31	12.28	12.10	12.43	12.28	12.28					
	F	−0 38.1	+ 4 16				13.29		13.80	13.54	13.54			13 36		13.71
	G	−1 24.4	+ 3 26				13.29		13.70	13.50	13.48			13.36		13.61
	H	−1 3.4	+ 1 35				13.48		13.96	13.72	13 70			13.55		13.86
	J	−1 32.3	+ 2 52				13.48		13.88	13.68	13.66			13.55		13.78
	K	−1 18.8	− 0 26				13.84		14.33	14.08	14 07			13.93		14.21
	L	+1 5.2	+16 22					13.76	13.79	13.78	13.70				13.70	13.70
	M	+2 26.8	− 1 42					14.06	13.97	14.02	13.93				13.99	13.87
	N	+2 17.3	+12 27					14.49	14.34	14.42	14.32				14.41	14.22
	O	+2 45.6	+ 6 13					14.61	14.77	14.69	14.58				14.53	14.63
	P	+2 9.1	+10 15					14.84	15.07	14.96	14.84				14.75	14.92
	Q	+1 38.9	+13 49		14.94	14.92			15.19	15.02	15.02	15.17	14.86			15.03
	R	+1 39.6	+11 47		15.05	15.04			15.25	15.11	15.12	15.28	14.98			15.09
	S	+1 22.7	+13 14		15.05	15.14			15.28	15.16	15.16	15.28	15.08			15.12
	T	+1 18.4	+13 27		15.18	15.39			15.22	15.26	15.27	15.42	15.32			15.06
	U	+1 29.6	+14 33		15.26	15.59			——	15.42	15.50	15.49	15.52			——

U Arietis $3^h\ 5^m\ 30^s + 14°\ 25'.3$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
6		+0 5.3	− 5 17													
17	A	−0 2.5	−11 2	12.60	12.67	12.49	12.75	12.53	12.44	12.58	12.58					
19	B	−0 26.0	+ 8 20	13.04	13.09	13.05	12.93	12.94	13.00	13.01	13.01					
21	C	+0 34.1	+ 6 37	13.19	13.20	13.11	13.22	13.12	13.17	13.17	13.17					
22	D	+0 12.9	+ 2 58	13.08	13.03	13.18	13.15	13.20	13.26	13.15	13.15					
23	E	−0 10.7	− 7 52	13.26	13.17	13.34	13.12	13.39	13.31	13.26	13.26					
	F	+1 6.9	+ 2.57				13.90		13.99	13.94	13.94			13.94		13.95
	G	+0 16.8	− 9 44				14.05		14.00	14.02	14.02			14.09		13.96
	H	+0 23.8	+ 7 26				14.13		14.05	14.09	14.10			14.18		14.01
	J	−0 33.2	− 1 47				14.14		14.17	14.16	14.16			14.19		14.12
	K	+0 30.3	− 7 19				14.59		14.72	14.66	14.65			14.66		14.64
	L	−0 21.3	+ 4 35					14.52	14.69	14.60	14.54				14.48	14.61
	M	−0 28.6	+ 5 5					14.92	15.05	14.98	14.91				14.86	14.96
	N	−0 24.0	+ 4 53					15.01	15.16	15.08	15.00				14.95	15.06
	O	+0 31.7	+ 9 44					15.14	15.78	15.46	15.36				15.08	15.65
	P	+0 34.2	+ 7 40					15.28	15.51	15.40	15.30				15.21	15.40
	Q	−0 1.5	−10 7		14.71	14.99			14.98	14.89	14.89	14.83	14.95			14.89
	R	−0 11.2	− 9 57		15.24	15.39			15.60	15.41	15.41	15.40	15.35			15.48
	S	−0 7.1	− 7 52		15.50	15.53			15.64	15.56	15.56	15.68	15.48			15.52
	T	−0 10.1	− 5 40		14.82	15.11			14.94	14.96	14.96	14.95	15.07			14.85
	U	−0 19.4	− 5 56		15.29	15.30			15.33	15.31	15.31	15.45	15.26			15.23

Northern Regions.

R Persei $3^h\ 23^m\ 41^s + 35^\circ\ 19'.6$ (1900).

Hagen	Star	Δα	Δδ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
17		+0 18.8	+ 7 34													
21		+0 39.8	+ 1 57													
23	A	+0 41.0	+13 6	10 86	11 20	11.17	11.22	11 17	10.98	11.10	11.10					
33	B	+0 28.4	+ 4 45	11 84	11.72	11 66	11.76	11 72	11.78	11.74	11.74					
34	C	−0 16.3	+ 8 24	11 72	11 64	11.71	11.67	11 71	11.66	11.68	11.68					
35	D	−0 13.8	+ 6 36	11.78	11 75	11.83	11 62	11 74	11.64	11.73	11.73					
36	E	+0 0.6	+ 5 7	11.85	11.75	11 67	11.78	11.72	12 00	11.79	11.79					
	F	+0 59 5	− 5 19				13 22		13 63	13.42	13.42			13.29		13.54
	G	+0 54 6	− 1 1				13.45		14.04	13.74	13.73			13 53		13.93
	H	+0 46 7	− 3 1				13 46		13.98	13.72	13.70			13.54		13.87
	J	+0 14 7	− 9 1				13 50		13 96	13.73	13.72			13.58		13.85
	K	+1 0 1	− 6 59				13 83		14.15	13 99	13.98			13 93		14.03
	L	+0 37.9	+13 21					13 86	14.30	14.08	13 98				13.79	14.18
	M	−0 15 5	+ 9 20					14 19	14.31	14.25	14.15				14.11	14.19
	N	−0 21.5	+ 5 34					14.35	14.69	14.52	14 41				14.27	14.55
	O	−0 0 8	+10 6					14 38	14.78	14.58	14.46				14 30	14.63
	P	+0 2 8	+ 2 31					15 58	15.32	15.45	15.30				15.46	15.15
	Q	−0 1 7	+13 4		14 44	14.99			15.14	14.86	14.85	14.64	14 93			14.98
	R	−0 3 4	+14 4		14.45	14.73			15.28	14.82	14.81	14.65	14 67			15.11
	S	−0 13.4	+13 12		15 11	15.37			——	15.24	15.33	15.36	15 30			——
	T	−0 13 5	+12 4		15 33	15.70			——	15.52	15.61	15.60	15 52			——
	U	−0 19.2	+12 45		15 48	15.63			——	15.56	15.66	15.75	15 56			——

V Tauri $4^h\ 46^m\ 15^s + 17^\circ\ 22'.1$ (1900).

Hagen	Star	Δα	Δδ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
5		+0 35 1	−12 9													
6		−0 43 6	−10 26													
8		−0 6 0	+ 6 1													
11		−0 20 5	− 4 45													
22	A	−0 17 3	− 8 49	12 44	12 42	— —	12 40	——	12.58	12.46	12.46					
24n	B*	+0 21 4	+9 52	12.52	12 66	——	12.71	12 81	——	12.68	12.68					
24s		+0 21 1	+10 0													
25	C	+0 12 0	+ 3 31	12 48	12 42	12 40	12 41	12 22	12 36	12.38	12.38					
27	D	+0 28 6	− 1 47	12 36	12.26	12 38	12 27	12.09	12 31	12.28	12 28					
30	E	+0 10 7	+ 9 54	12.44	12 47	12 51	12.45	12 70	12.46	12.50	12 50					
	F	+1 3 0	− 0 48				13 66		13 71	13 68	13 68			13 71		13 65
	G	+0 39 7	− 4 3				13 67		14 06	13 86	13 86			13 72		13 99
	H	+0 57 0	+ 4 25				13.86		13.91	13.88	13 88			13 92		13 84
	J	+0 48 2	+ 2 28				13.98		14 12	14.05	14 04			14 05		14.04
	K*	+0 57 5	+ 2 11				14 14		——	14.14	14 21			14 21		——
	L	−0 10.9	+ 4 31					14 51	14 59	14 55	14 47				14 45	14.49
	M = S	+0 16.6	+10 22		14 31	14 80		14 58	14 82	14 63	14 61	14 44	14 76		14 52	14.71
	N = R	+0 1.9	+ 8 57		14 53	14 86		15 33	15 05	14 94	14 93	14 68	14 82		15 25	14 93
	O = Q	−0 0.2	+ 8 36		14 78	15 33		15 42	15 23	15 19	15 16	14 95	15 28		15 33	15 10
	P = U	+0 7.2	+ 9 5		15 17	15 53		15 53	15 26	15 37	15.34	15.36	15 47		15 44	15 13
	Q = O	−0 0 2	+ 8 36		14 78	15 33		15 42	15 23	15 19	15 16	14 95	15 28		15 33	15 10
	R = N	+0 1 9	+ 8 57		14 53	14 86		15 33	15 05	14 94	14 93	14 68	14 82		15 25	14 93
	S = M	+0 16 6	+10 22		14 31	14 80		14 58	14 82	14 63	14 61	14 44	14 76		14 52	14 71
	T	+0 17.0	+ 7 22		15 12	15 38			15 57	15 34	15 34	15 31	15 28			15 43
	U = P	+0 7.2	+ 9 5		15 17	15 53		15 53	15 26	15 37	15 34	15 36	15 47		15 44	15 13

* Stars B and K are double.

Northern Regions.

V Aurigae 6 16 30 + 47 45.3 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
7		−1 22.5	+16 25													
9		−0 14.3	+16 32													
12		+1 38.5	− 6 33													
22	A	−0 17.9	− 6 46	11.64	11.86	11.75	11.90	11.71	11 79	11.76	11.76					
27	B	−0 17.6	−10 26	12.27	12.45	12 38	12.50	12.36	12 45	12 40	12 40					
30	C	−0 14.2	− 4 15	12 61	12 35	12 50	12 19	12.47	12 27	12 10	12 40					
31	D	−0 5.4	+ 7 44	12.35	12.25	12.36	12.46	12.38	12 30	12 35	12 35					
35	E	−0 13.5	+ 7 21	12.62	12.57	12.50	12.44	12 59	12 68	12 57	12.57					
	F	+0 12.3	+ 3 1				13.41		13 42	13.42	13.42			13.46		13.37
	G	+0 49.5	− 3 34				13.48		13 70	13 59	13 58			13 53		13.64
	H	+0 21.5	+ 0 49				13 55		13 92	13.74	13.72			13 60		13.85
	J	+0 28.8	− 4 38				13.58		13 92	13 75	13 74			13 63		13.85
	K	+0 41.0	− 0 22				13.64		14 05	13 84	13.84			13.70		13.97
	L	−0 1.0	− 7 0					14 42	14 84	14.63	14 54				14 36	14.72
	M	−0 11.4	− 9 48					14 64	14 85	14 74	14 65				14.57	14.73
	N	−0 15.8	− 8 20					14 97	15 60	15 28	15 17				14.89	15.45
	O	−0 14.5	+ 8 41					15.07	15 78	15 42	15 30				14.99	15.62
	P	−0 7 1	+ 8 53					15.32	15 81	15 56	15 44				15.23	15.65
	Q	−0 8.2	+ 2 22		13.94	14.55			14 59	14 36	14 35	14 06	14 51			14.49
	R	−0 7 4	+ 6 41		14.22	14.77			14 81	14 60	14 59	14.36	14.72			14.70
	S	+0 5.7	+ 6 48		14 61	15.32			15 28	15 07	15 06	14.77	15.26			15.14
	T	+0 0.2	+ 3 26		14.42	15.04			14 95	14 80	14.80	14.57	14.99			14.83
	U	−0 3.0	+ 3 54		14 67	15.32			15 51	15 17	15 15	14.84	15.26			15.36

R Geminorum 7 1 20 + 22 51.5 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
3		−0 2.9	−11 40													
6		+0 1.9	+ 5 32													
8		−0 46.4	+ 9 24													
9		+0 25 8	+ 3 15													
11		+0 6.4	+15 59													
27	A	−0 32.8	− 9 14	11 93	11.84	11 81	11.88	11 85	12.07	11.90	11.90					
28	B	−0 18.0	− 7 55	11.46	11.75	11.65	11.70	11.57	11 60	11.62	11 62					
37	C	+0 7.4	−13 35	12.27	12.18	12.18	12.17	12 21	12 08	12.18	12.18					
38	D	−0 3.3	− 6 33	12.14	12.03	12.12	12.04	12.19	12 04	12 09	12.09					
44	E	+0 15.5	−10 28	12.84	12.51	12.45	12.36	12.48	——	*						
	F	+1 6.2	+ 2 58				12.72		13 18	12.95	12.94			12.75		13.12
	G	+1 3.9	+ 3 55				12.76		12.96	12 86	12.85			12 79		12.91
	H						12.88		13.01	12.94	12.94			12.92		12.96
	J	+1 7.7	+ 4 42				13.06		13.30	13.18	13.18			13.11		13.24
	K	+1 1.3	+ 4 24				14.19		14 34	14.26	14.26			14.29		14.23
	L	+0 48.9	+ 3 13					13 67	13.59	13.63	13 56				13.62	13.51
	M	+0 44.6	+ 6 42					14.15	13 97	14.06	13.99				14.09	13.89
	N	+0 41.1	+ 3 28					14.72	14.70	14.71	14 60				14.64	14.57
	O	+0 36.7	+ 3 58					14.76	14 83	14 80	14.69				14.68	14.70
	P	+0 45.3	+ 8 16					15.12	15.38	15.25	15.12				15.03	15.22
	Q	+0 9.1	− 7 43		14.66	15.26			15 16	15.03	15.02	14.85	15.20			15.01
	R	−0 0.1	− 7 56		14.79	— –			15 19	14 99	15.00	14.98	——			15 04
	S	+0 4.2	− 8 18		14.95	15.64			15.61	15 40	15.39	15.16	15.57			15 11
	T	+0 6.8	− 8 14		14.98	15 80			15.40	15 39	15 39	15.19	15.73			15 24
	U	−0 7.1	− 6 20		14.69	15.27			15.11	15.02	15.02	14.88	15.21			14.97
						14.02							13 98			

* Star E is the variable Z Geminorum.

Northern Regions.

V Cancri 8 16 1 + 17 36.1 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
4		+0 10.4	+19 5													
8		−0 15.4	+22 39													
10		+0 12.4	+15 2													
14		−0 29.7	+21 45													
23		+0 2.4	+22 37													
24	A	+0 17.5	+ 0 20	11.33	11.51	11 67	11.67	11.46	11 58	11.54	11.54					
26	B	+0 36 2	− 6 14	11.74	11.77	11 82	12.02	11.75	11.55	11.77	11.77					
27	C	−0 36.4	+ 0 58	12.05	12.09	12.01	11.89	12 17	12.08	12.03	12.03					
38	D	+0 5.4	+ 7 59	12.59	12 54	12.34	12.29	12 50	12.56	12.47	12.47					
39	E	+0 26.2	+ 8 14	12.55	12.36	12.43	12.40	12.37	12.50	12.44	12.44					
	F	+0 4.3	+ 6 22				13.14		13.42	13.28	13.28			13.19		13 36
	G	+0 31 7	+ 5 47				13.21		13 50	13.36	13.34			13 26		13 43
	H	+0 18.2	+ 2 1				13.50		13.58	13.54	13.54			13.56		13 51
	J	+0 1.9	− 7 19				13.54		13 66	13 60	13.60			13 60		13 59
	K	−0 20.5	+ 0 31				13.55		13 74	13.64	13.64			13.61		13 66
	L	+0 33.0	− 0 54					14.59	14.80	14.70	14.60				14.52	14 67
	M	+0 32 3	− 4 30					14.62	14.76	14.69	14.59				14 54	14 64
	N	+0 40.2	− 2 43					15.41	15 80	15 60	15.47				15.31	15 63
	O	+0 29 2	− 5 45					15 72	15 84	15 78	15.64				15 61	15 67
	P	+0 29.6	− 6 44					15.77	——	15.77	15.66				15 66	——
	Q	+0 34 6	+ 6 51		14 17	14.57			14.95	14.56	14.55	14.32	14.52			14 82
	R	+0 39 5	+ 6 27		14 76	14.98			15.50	15.08	15.07	14.95	14 93			15 34
	S	+0 18 9	+ 9 16		14 48	14.81			14.97	14.75	14.75	14.65	14 76			14 84
	T	+0 34.5	+ 9 36		15 54	15.58			16.10	15.74	15.74	15 79	15.51			15 91
	U	+0 42.8	+ 6 53		15 54	15.68			16.17	15.80	15.79	15.79	15.61			15 98

R Leonis Minoris 9 39 35 + 34 58.3 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
26	A	+0 34.4	+ 4 21	12 29	12 36	12 36	12 42	12.42	12 25	12.35	12 35					
27	B	−1 9.5	−10 56	12.63	12.85	12 76	12.66	12 56	12.66	12 68	12.68					
29	C	+0 16.1	− 5 47	13 03	12 97	13 00	13.02	13 30	13 24	13 09	13.09					
30	D	+0 22.9	− 5 35	12 97	12 85	12 86	12.92	12.86	12 89	12 89	12.89					
31	E	−0 46.2	− 8 13	13 35	13 25	13 29	13 25	13 13	13 23	13 25	13.25					
	F	+0 34 5	+12 46				13.65		13 45	13 55	13.55			13 68		13 42
	G	+0 32.7	+ 8 22				13 67		13.59	13 63	13 63			13 70		13 56
	H	+0 19 1	− 2 37				13 81		13.74	13 78	13 78			13 85		13 70
	J	−0 21.2	+ 3 17				14.56		14 69	14 62	14 62			14.63		14 61
	K	−0 6 2	+ 9 1				14 61		14 64	14 62	14 62			14.69		14 56
	L=S	+0 10 4	− 7 30		15 19	15 20		15 15	15.26	15 20	15 19	15 35	15 16		15 08	15 15
	M=U	+0 27.6	− 2 48		15 35	15 42		15 25	15 35	15 34	15 33	15.53	15 37		15 18	15 24
	N	+0 19 9	− 0 59					15 62	15 86	15 74	15 63				15 54	15 72
	O	+0 14 6	− 7 57					15 62	15 92	15 77	15 66				15 54	15 78
	P	+0 25 4	− 9 36					15 85	16 17	16 01	15 90				15 77	16 02
	Q	+0 54 4	−11 26		14 29	14 47			14 52	14 43	14 42	14 39	14 44			14 44
	R	+0 39 1	− 3 30		14 70	14 62			14 70	14 67	14 68	14 82	14 59			14 62
	S=L	+0 10 4	− 7 30		15 19	15 20		15 15	15 26	15 20	15 19	15 35	15 16		15 08	15 15
	T	+0 41 2	− 5 32		15 05	15 07			15 26	15 13	15 13	15 21	15 03			15 15
	U=M	+0 27.6	− 2 48		15 35	15 42		15 25	15 35	15 34	15 33	15 53	15 37		15 18	15 24

Northern Regions.

W Leonis 10 48 21 + 14 14.9 (1900)

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
6		−0 55.6	+13 29													
9		−0 23.8	−14 25													
20	A	+0 57.2	− 5 38	12.30	12.44	12.47	12.42	12.45	12.27	12.39	12.39					
22	B	+0 50.8	+ 2 21	12.32	12.42	12.29	12.39	12.21	12.28	12.32	12.32					
23	C	+0 34.3	− 7 15	12.72	12.54	12.56	12.57	12.78	12.52	12.62	12.62					
24	D	+0 16.8	− 2 14	12.71	12.64	12.74	12.66	12.60	12.73	12.67	12.67					
27	E	+0 17.1	− 8 32	12.88	12.88	12.86	12.88	12.89	13.14	12.92	12.92					
	F	+0 21.9	+ 3 40				13.72		14.08	13.90	13.89			13.77		14.01
	G	+0 22.5	+ 6 21				13.97		14.31	14.14	14.13			14.03		14.23
	H						13.97		14.28	14.12	14.12			14.03		14.20
	J	+1 21.6	+ 5 38				14 37		14.58	14.48	14.47			14.45		14.49
	K	+0 38.4	+ 5 22				14.48		14.56	14.52	14.52			14.56		14.47
	L	+1 11.3	+ 1 27					14.66	14 88	14.77	14.69				14.60	14.78
	M	+1 2.9	− 4 40					15.15	15.61	15.38	15 28				15.08	15.47
	N	+0 45.3	− 3 43					15.27	15.72	15.50	15 38				15.19	15.58
	O	+0 40.2	− 4 54					15 32	15 64	15.48	15.37				15.24	15 50
	P	+0 26.2	− 6 0					15.58	16.00	15.79	15.66				15.49	15.84
	Q	+0 44.6	+ 0 37		15.32	15 56			15.98	15.62	15.62	15.52	15.50			15.82
	R	+0 32.0	+ 0 55		15.15	15.43			15.84	15.47	15.47	15 34	15.38			15 69
	S	+0 28 0	+ 1 15		15.47	15.63			16.00	15.70	15.70	15.68	15.57			15.84
	T	+0 13.9	+ 7 42		15.81	16.12			——	15.96	16.05	16.04	16.06			——
	U	+0 6.4	+ 5.39		15.30	15.32			15.85	15.49	15.49	15.50	15.27			15.70

T Ursae Majoris 12 31 50 + 60 2.3 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
9		+2 7.6	+12 30													
11		+1 50.3	−14 11													
14		+2 3.7	+ 8 21													
22		−0 4.4	−12 16													
20	A	−0 32.8	+ 1 57	12.51	12.60	12.54	12.62	12.62	12.66	12.59	12.59					
21	B	+0 56.5	− 3 54	12.71	12.86	12.65	12.66	12.50	12.64	12.67	12.67					
23	C	−0 39.3	−13 48	13.39	13.09	13.28	13.27	13.33	13.28	13.27	13.27					
24	D	+0 4.5	+ 8 29	13.24	12.91	13.33	13.31	13.32	13.23	13.22	13.22					
26	E	+0 14.6	+14 23	13.15	13.54	13.20	——	13.23	13.18	13.26	13.26					
	F	+1 12.2	− 3 43				13.48		13.56	13.52	13.52			13.50		13.53
	G	+1 11.6	+ 6 23				13.94		13.70	13.82	13.82			13.98		13.67
	H	+0 23.8	− 1 6				14.03		14.14	14.08	14.08			14.07		14 09
	J	+1 22.5	+ 7 17				14.50		14.59	14.54	14.54			14.56		14.52
	K	+0 37.6	− 0 15				14.73		14.83	14.78	14.78			14.81		14.75
	L	+1 46.7	−10 59					14.51	14.68	14.60	14.54				14.47	14.60
	M=S	+1 4.1	− 3 10		14.85	14.93		15.04	15.00	14.96	14.94	14.98	14.89		14.98	14.91
	N	+2 8 1	− 9 12					15.72	15.78	15.75	15.64				15.64	15.65
	O	+1 9.9	− 6 21					15.85	15.74	15.80	15.69				15.77	15.61
	P	+1 59.9	−12 18					15.97	15.87	15.92	15.82				15.89	15.74
	Q	−0 30.6	+ 4.20		15.15	15.45			15.54	15.38	15.38	15.30	15.41			15.42
	R	+0 58.5	− 0 46		14.88	15.02			15.15	15.02	15.02	15.01	14.98			15.05
	S=M	+1 4.1	− 3 10		14.85	14.93		15.04	15.00	14.96	14.94	14.98	14.89		14.98	14.91
	T	+0 29.4	− 3.14		15.65	15.85			15.84	15.78	15.78	15.84	15.80			15.71
	U	+0 18.0	− 5 34		16.08	16.28			16.04	16.13	16.14	16.30	16.22			15.90

Northern Regions.

U Virginis $12^h\ 46^m\ 1^s + 6^\circ\ 5.8$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
15	A	+0 59.1	+ 5 25	11 22	11.34	11.43	11 60	11.52	11.19	11.38	11.38					
16	B	+0 23 6	+ 0 35	11 39	11.67	11.47	11 50	11 50	11.42	11 49	11.49					
17	C	+0 47 0	− 1 6	12 19	12.26	12.11	12 29	12 14	12 14	12 19	12.19					
18	D	−0 58 7	+ 1 23	12 63	12.55	12.60	12 41	12 60	12 69	12 58	12 58					
19	E	−0 16 6	− 9 2	13 00	12.64	12.83	12 63	12.67	13.00	12.80	12.80					
	F	+0 51 6	+ 1 45				13 49		13 50	13 50	13 50			13 55		13 44
	G	−0 20 6	+ 6 50				13 61		13 54	13 58	13 58			13 68		13 48
	H	−0 0 1	+ 3 29				13 65		13 72	13 68	13 68			13.72		13 65
	J	−0 30 3	− 3 53				14 00		14 18	14 09	14.08			14 08		14 08
	K	−0 1 2	+ 5 35				14 06		14.12	14.09	14 08			14 14		14 03
	L	+0 27.0	+ 2 16					14 56	14 72	14 64	14 54				14 49	14 60
	M=S	+0 29.9	− 0 17		14.94	14.96		14.90	15.16	14.99	14.98	15.15	14.91		14 82	15 02
	N=R	+0 33.0	+ 0 47		15.17	15.53		15.49	15.62	15.45	15.43	15.39	15.47		15 39	15 46
	O=U	+0 40.9	+ 0 59		15.51	15.90		15.66	15.83	15.72	15.70	15.76	15.83		15 56	15 66
	P=T	+0 26.7	− 0 38		15.36	15.67		15.76	15.58	15.59	15.57	15.60	15.60		15 65	15 42
	Q	+0 41.2	− 1 4		14.48	14.95			14.79	14.74	14.74	14.65	14.90			14 67
	R=N	+0 33.0	+ 0 47		15.17	15.53		15.49	15.62	15.45	15.43	15.39	15.47		15 39	15 46
	S=M	+0 29.9	− 0 17		14.94	14.96		14.90	15.16	14.99	14.98	15.15	14.91		14 82	15 02
	T=P	+0 26.7	− 0 38		15.36	15.67		15.76	15.58	15.59	15.57	15.60	15.60		15 65	15 42
	U=O	+0 40.9	+ 0 59		15.51	15.90		15.66	15.83	15.72	15.70	15.76	15.83		15 56	15 66

S Bootis $14^h\ 19^m\ 32^s + 54^\circ\ 15.9$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
2		−0 55 6	−17 12													
11		+0 23 5	−14 31													
21	A	+1 8 8	+ 7 38	12 30	12 13	12 27	12.29	12 28	12 02	12 22	12 22					
22	B	−0 4 0	+ 3 55	12.40	12 44	12 51	12 50	12 40	12 44	12.45	12 45					
23	C	−1 9.0	− 6 18	12 64	12 82	12 70	12 66	12 74	12 82	12 73	12 73					
24	D	−1 8.8	+14 30	12 84	12 90	12 75	12 80	12.81	12 91	12 84	12 84					
25	E	+0 15.9	− 4 22	12.84	12 73	12 80	12.76	12.79	12.84	12.79	12.79					
	F						13 92		13 73	13 82	13 82			13 98		13 68
	G						13 93		13 80	13 86	13 87			13 99		13 75
	H	+0 55.5	− 0 48				13 98		13 66	13.82	13 82			14 04		13.61
	J	+1 14.4	+ 1 38				14 24		14 05	14 14	14 14			14 31		13.98
	K	+1 10.6	+ 1 28				14 33		14 37	14 35	14 35			14 41		14 29
	L=R	+0 39 2	+ 2 28		14.81	14 65		14 74	14 89	14 77	14 76	14 97	14 61		14.68	14 79
	M=S	+0 40 0	− 0 57		15.00	14 95		15 23	15 15	15 08	15 06	15 17	14 91		15 15	15 03
	N=T	+0 51.7	− 3 19		15.51	15 30		15 36	15 52	15 42	15 40	15 71	15 25		15 26	15 39
	O=U	+0 52.4	− 4 28		15.62	15 50		15 58	15 56	15 56	15 55	15 84	15.45		15 49	15 43
	P	+0 48 7	− 2 41					16 15	15 94	16 04	15 92				16 05	15 79
	Q	+0 56 7	+ 2 30		14.94	14 88			15 09	14 97	14 97	15 10	14 84			14 98
	R=L	+0 39 2	+ 2 28		14.81	14 65		14 74	14 89	14 77	14 76	14 97	14 61		14 68	14 79
	S=M	+0 40 0	− 0 57		15.00	14 95		15 23	15 15	15 08	15 06	15 17	14 91		15 15	15 03
	T=N	+0 51.7	− 3 19		15.51	15 30		15 36	15 52	15 42	15 40	15 71	15 25		15 26	15 39
	U=O	+0 52 4	− 4 28		15.62	15 50		15 58	15 56	15 56	15 55	15 84	15 45		15 49	15 43

Northern Regions.

R Camelopardalis $14^h\ 25^m\ 6^s + 84^\circ\ 17'.1$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B
		m s	′ ″											
1		−3 20.6	+ 7 10											
4		+7 24.3	− 7 22											
7		+5 29.6	+11 16											
10		+5 48.2	− 2 29											
11		−1 35.2	+ 4 47											
13	A	+3 58.3	+ 5 47	11.55	11.82	11 69	11.62	——	11 67	11.67				
14	B	+8 39.7	+ 7 47	12.49	12.14	12.24	12.17	12.17	12 24	12.24				
16	C	−4 44.1	+12 7	12.29	12.23	12 35	12.25	12.19	12 26	12.26				
18	D	−6 45.4	+11 36	12 54	12.46	12.59	12 61	——	12 55	12 55				
19	E	+6 22.1	+ 3 33	12.43	12 65	——	12.65	12 85	12.64	12.64				
	F	−0 55 6	−10 48				13.59		13 59	13 65			13.65	
	G	−4 33 0	+ 1 11				13 99		13 99	14.07			14 07	
	H	−0 41.4	− 6 35				14 02		14 02	14 10			14 10	
	J	+1 30.1	− 5 19				14 10		14 10	14 18			14 18	
	K	+7 8.4	− 3 10				14 12		14.12	14 20			14 20	
	L	+8 9.4	− 0 1					14 03	14 03	13 98				13.98
	M	+9 9 8	+ 0 34					14 52	14.53	14.45				14 45
	N	+7 45 9	− 1 55					15 25	15.25	15.16				15.16
	O	+5 48 9	− 8 19					15 59	15.59	15 49				15.49
	P	+6 56.1	− 0 2					15 73	15.73	15 63				15.63
	Q	−0 57.8	− 7 37		14.73	14.63			14.68	14 74	14.90	14 59		
	R	−2 41.8	− 9 7		14.90	14.95			14.93	14.99	15 08	14.90		
	S	−1 42.7	− 9 5		15.48	15.54			15.51	15 59	15.70	15 48		
	T	−1 43.2	− 9 40		15.65	15.74			15.70	15 78	15 88	15 68		
	U	−1 39.2	−10 39		15.75	15.89			15.82	15.90	15 99	15 82		

R Serpentis $15^h\ 46^m\ 5^s + 15^\circ\ 26'.3$ (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
5		+1 12.6	−16 59													
10		+1 6.4	−10 20													
15	A	−0 27.8	− 6 43	11.36	11.47	11 37	11.57	11.54	11.43	11 46	11 46					
16	B	−0 42.1	−11 51	11.24	11.48	11.45	11.34	11.37	11.38	11 38	11 38					
17	C	−0 37.8	− 3 19	11.59	11.49	11.53	11.56	11 59	11 58	11 56	11 56					
20	D	−0 49.0	+ 3 43	12.21	11.95	12.03	11.95	11.94	11 98	12.01	12 01					
21	E	−0 36.2	+ 6 1	12.29	12.31	12.32	12.27	12 24	12.33	12.29	12.29					
	F	+0 26.9	+ 8 59				13.40		13 39	13 40	13 39			13.47		13.31
	G	+0 44.4	+ 7 2				13.59		13 60	13.60	13.59			13.67		13.51
	H	+0 33.0	− 2 33				13.85		13.92	13 88	13 88			13.94		13 82
	J	+0 49.7	+ 3 32				13.93		13 90	13 92	13 92			14.03		13 80
	K	+0 52.2	+ 4 38				13.93		14.18	14.06	14 05			14.03		14 07
	L	−0 52.6	− 8 16					14.32	14.04	14.18	14 09				14.24	13.94
	M=R	−0 45.9	− 9 24		14.31	14.73		14 97	14 60	14 65	14 63	14.49	14.67		14.88	14.47
	N	−0 56.8	+ 2 2					15.01	14.80	14 90	14 78				14.91	14.66
	O	−0 38.4	+ 5 47					15 29	14 51	14.90	14.78				15.19	14.38
	P	−0 40.7	− 4 16					15.32	14.79	15.06	14.94				15.22	14.65
	Q	−0 39.4	−10 27		13.77	14.05			14.26	14 03	14.02	13.91	14.01			14 14
	R=M	−0 45.9	− 9 24		14.31	14.73		14.97	14.60	14.65	14.63	14.49	14 67		14.88	14.47
	S	−0 40.9	− 9 38		14.73	14.99			15.10	14.94	14.94	14.95	14.93			14.95
	T	−0 37.2	− 9 45		15.15	15.32			15.46	15.31	15.31	15.39	15.25			15.29
	U	−0 29.5	− 8 8		15.47	15.53			15.49	15.49	15.51	15.74	15.46			15.32

Northern Regions.

W Herculis $16^h\ 31^m\ 41^s + 37^\circ\ 32'.4$ (1900).

Hagen	Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		^{m} ^{s}	$'$ $''$													
1		+2 14 9	+ 8 24													
2		+0 11 0	−26 15													
4		+0 1 6	−19 35													
5		+0 17 4	+25 33													
7		+1 39 8	−26 17													
8		+2 26 3	− 2 32													
9		+0 17 8	+ 6 19													
11		+1 4.0	−26 18													
18		+0 36 5	+ 8 40													
19	A	+0 22 7	− 1 1	11 51	11.40	11 49	11.56	11 55	11 45	11.49	11.49					
20	B	−0 45 5	− 9 55	11 62	11 67	11 68	11 70	11 60	11 73	11 67	11.67					
21	C	+0 59 3	−14 1	11 33	11.27	11 46	11 51	11 50	11 51	11 43	11 43					
22	D	+1 46.3	− 8 33	11 96	11 90	11.87	11 79	11 86	11.92	11 88	11.88					
24	E	+1 31.4	− 0 46	12 20	12 38	12.13	12.06	12.11	12.02	12.15	12 15					
	F	+0 30.6	− 5 10				13.74		13 82	13 78	13.78			13 83		13.72
	G	+0 57.6	+ 4 10				13 96		14 34	14.15	14 14			14.06		14.22
	H	+1 7.0	− 4 1				14 01		14 20	14 10	14 10			14 11		14.09
	J	+1 3.8	− 0 13				14 04		14 26	14 15	14.14			14.14		14.14
	K	+0 41.3	− 1 23				14 05		14.38	14.22	14.20			14.15		14 26
	L	+1 1.4	− 9 50					13 85	13.78	13 82	13 74				13 79	13 69
	M	+1 2.7	−10 36					14 29	14.02	14.16	14 06				14 21	13 92
	N	+1 17.4	−15 21					15.22	15.16	15 19	15.06				15 12	15 00
	O	+1 22.5	−14 14					15.35	15.22	15.28	15.15				15 24	15 06
	P	+1 0.7	−15 31					16 11	15.98	16.04	15 88				15 98	15 78
	Q	+0 44 1	− 8 6		14 69	15 43			15 44	15 17	15 18	14 90	15 36			15.27
	R	+0 48 3	− 9 12		15 14	15 88			15.80	15 61	15.60	15 38	15 80			15 61
	S	+0 53 9	− 7 36		15 60	16 38			15.90	15.96	15 95	15 88	16 29			15 71
	T	+0 52 1	−13 58		15 62	16 27			15.94	15 94	15 95	15 90	16 19			15 75
	U	+0 54 1	−13 2		15 81	16 62			—	16.22	16 32	16 10	16 53			—

Northern Regions.

R Draconis $16^h\ 32^m\ 23^s + 66^\circ\ 57'.8$ (1900).

Hagen	Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Yerk.	Lick	McCormick A	McCormick B	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B
		$m\ s$	$'\ ''$											
1		−4 8.6	+17 58											
2		−7 19.8	+20 4											
4		+0 51.8	− 1 19											
5		+5 13.3	+19 48											
6		−1 21.4	−30 8											
7		+1 26.5	−27 12											
9		−2 48.9	+ 2 49											
12		−1 20.7	− 1 58											
13		+3 57.5	+ 5 5											
16		−0 57.7	+ 7 41											
18	A	+0 27.8	− 9 30	11.12	11.30	11.50	11.38	11.32	11.32	11.32				
19	B	−0 4.1	−10 11	11.82	11.73	11.82	11.70	11.74	11.76	11.76				
20	C	−0 22.8	−11 21	12.20	12.35	12.17	12.23	12.32	12.25	12.25				
21	D	−2 20.7	−10 56	12.38	12.45	12.38	12.38	12.60	12.44	12.44				
22	E	+1 48.4	+ 0 39	12.67	12.38	12.33	12.50	12.22	12.42	12.42				
	F	+0 53.8	− 8 4				13.62		13.62	13.69			13.69	
	G	+1 8.8	− 5 40				14.07		14.07	14.16			14.16	
	H	+2 12.9	− 3 14				14.20		14.20	14.29			14.29	
	J	−0 7.3	+ 5 10				14.25		14.25	14.35			14.35	
	K	+2 14.4	+ 0 25				14.48		14.48	14.59			14.59	
	L	+0 30.6	− 6 12					14.14	14.14	14.08				14.08
	M	−0 41.6	−13 34					14.18	14.18	14.12				14.12
	N	−0 26.6	− 8 44					14.38	14.38	14.31				14.31
	O	+0 19.2	−11 30					14.79	14.79	14.71				14.71
	P	−0 9.1	− 8 0					15.11	15.11	15.02				15.02
	Q	+1 43.9	+ 5 32			16.43						16.35		
	R	+2 8.9	+ 7 33			16.57						16.49		
	S	+1 19.7	+ 4 30			16.70						16.61		
	T	+2 21.4	+ 1 34			16.76						16.67		
	U	+2 9.1	+ 3 56			16.96						16.87		
	q	+1 53.0	+ 3 59		15.09						15.31			
	r	+1 44.8	+ 4 29		15.46						15.71			
	s	+1 32.6	+ 2 8		15.44						15.69			
	t	+1 34.0	− 1 2		14.98						15.19			
	u	+1 18.3	− 4 0		14.91						15.12			

Northern Regions.

S Herculis 16h 47m 21s + 15° 6′.6 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick			Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick		
							A	B	C					A	B	C
		m s	′ ″													
1		+0 11.0	+ 1 56													
2		−1 55.3	+26 25													
5		+1 9.9	− 3 31													
6		−1 2.2	− 5 59													
7		+1 54.6	− 8 7													
8		+1 32.1	+ 2 20													
9		+0 13.7	−10 29													
10		+0 9.1	− 1 25													
15	A	+0 40.1	−11 17	11.25	11.38	11.32	11.28	11.36	11.40	11.33	11.33					
16	B	+0 50.6	− 3 1	11 41	11.52	11.50	11.42	11.40	11.53	11.46	11.46					
17	C	+0 22.4	− 7 59	11.61	11.40	11.52	11.52	11.57	11.40	11.50	11.50					
18	D	+0 15.8	− 6 19	12.07	11.77	11.94	12.18	11.77	11.86	11.93	11.93					
21	E	+0 24.9	−12 14	11.66	11.93	11.72	11.60	11.89	11.81	11.77	11.77					
	F	−0 45.5	− 3 38				13.34		13.37	13.36	13.36			13.42		13.29
	G	−0 43.4	− 4 56				13.36		13.40	13.38	13.38			13.44		13.32
	H	−0 48.8	− 1 44				13.52		13.59	13.56	13.55			13.60		13.50
	J						13.62		14.26					13.71		14.14
	K	−0 49.3	+ 1 13				14.07		14.04	14.06	14.06			14.18		13.93
	L	+1 13.3	− 6 1					14.29	14.47	14.38	14.28				14.21	14.34
	M	+0 29.5	−13 3					14.31	14.80	14.56	14.44				14.23	14.65
	N	+0 10.3	− 7 56					14 35	14.86	14.60	14.49				14.27	14.71
	O	+1 4.2	− 5 51					14.86	15.30	15.08	14.94				14.76	15.13
	P	+2 24.6	− 2 17					15.27	15.46	15.36	15.22				15.16	15.28
	Q	+0 53.2	− 1 30		14.96	15.31			15.82	15.36	15.36	15.20	15.24			15.63
	R	+0 44.0	− 2 49		15.16	16.04			15.70	15.63	15.63	15.42	15.96			15.51
	S	+0 50.9	− 2 19		15.42	15.65			15.74	15.60	15.60	15.69	15.57			15.55
	T	+0 44.1	− 0 55			16.16				——	——		16.08			
	U	+0 43.1	− 2 24			15.94				——	——		15.86			
	t	+0 37.8	− 1 31		15.25							15.51				
	u	+0 38.5	− 1 52		14.62							14.84				

Northern Regions.

R Aquilae 19 1 33 + 8 4.8 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
4		−1 28.5	+14 53													
5		+0 49.2	+ 6 57													
6		−1 24.4	− 0 42													
7		+0 52.7	− 6 31													
8		+1 2.8	− 3 2													
12		−0 0.5	−17 55													
23		−0 11.9	− 0 35													
24	A	−0 11.8	+ 5 28	11.52	11.33	11.54	11.54	11.51	11.45	11.48	11.48					
26	B	+0 54.1	+ 3 11	11.67	11.76	11.67	11.87	11.68	11.88	11.75	11.75					
29	C	−0 53.0	+ 6 17	11.85	11.93	11.71	11.73	11 70	11 85	11.80	11.80					
31	D	−0 34.5	+ 6 24	11.70	11.89	11.82	11.85	11.84	11.74	11.81	11.81					
33	E	−0 55.0	− 9 47	12.16	11.99	——	11.92	——	11.99	12.01	12.01					
	F	+0 37.1	+ 0 21				13.08		12.91	13.00	13.00			13.14		12.86
	G	+0 37.5	− 5 55				13.25		13.03	13.14	13.14			13.31		12.97
	H	+0 46.4	− 3 6				13.26		13.15	13.20	13.20			13.32		13.09
	J	+0 35.8	+ 4 29				13.72		13.75	13.74	13.73			13.80		13.66
	K	+0 16.5	+ 5 44				13.72		13.48	13.60	13.60			13.80		13.40
	L	+1 7.2	− 1 24					14.61	14.50	14.56	14.46				14.53	14.38
	M	+0 42.0	− 0 30					14.73	14.28	14.50	14.40				14.64	14.17
	N	+0 41.1	− 0 3					14.87	14.53	14.70	14.60				14.78	14.40
	O	+1 14.2	− 2 40					14.88	14.94	14.91	14.80				14.79	14.80
	P	+0 43.4	− 4 52					15.05	15 01	15.03	14.90				14.95	14.86
	Q	+0 9.6	+ 6 6		14.97	15.31			15.74	15.34	15.34	15.20	15.25			15.56
	R	+0 15.4	+ 7 7		15.06	15 39			15.56	15.34	15.34	15.30	15.32			15.39
	S	+0 37.0	+ 5 41		15.47	15.91				15.68	15.78	15.73	15 83			
	T	+0 24.8	+ 5 3		15.69	15.94				15.82	15.92	15.97	15.86			
	U	+0 39.0	+ 2 50		15.50	16.01				15.76	15.85	15 77	15.93			

Northern Regions.

χ *Cygni* 19 46 44 + 32 39.7 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	′ ″													
3		−1 41.6	+31 31													
7		−0 30 6	−16 24													
13		+0 54.9	+10 56													
14		−1 29 2	−17 24													
20		−1 0 8	+ 2 36													
24		+0 36 6	−19 6													
59	A	+0 23 4	− 2 9	10.73	10.56	10.69	10.84	10.68	10 88	10.73	10.73					
63	B	+0 39 4	+ 0 19	11.17	11 07	11.09	10.97	11.32	11 02	11 11	11 11					
64	C	+0 28 1	+ 3 45	11 23	11 11	11.11	11.07	10.92	10 96	11 07	11 07					
67	D	+0 14 8	+ 2 34	11 16	11 41	11.21	11.27	11.39	11 36	11 30	11 30					
81	E	+0 2 7	+ 7 36	11 25	11 39	11.43	11.38	11.23	11 33	11 34	11.34					
	F	+0 55 2	+ 1 30				12.04		12.40	12 22	12 21			12 08		12.34
	G	+0 42 4	+ 5 15				12 30		12 57	12 44	12 42			12 35		12 50
	H	+1 5 8	+ 3 53				12.36		12 70	12 53	12 52			12 41		12 63
	J	+0 46 6	+ 0 26				12 80		13.14	12 97	12 96			12 87		13 05
	K	+0 50 4	+ 6 56				12 91		13.42	13.16	13 15			12 99		13 31
	L	+0 7 3	+ 5 3					13 20	13.31	13.26	13.18				13 14	13 21
	M	+0 44 1	+ 2 55					13 60	13 56	13.58	13 49				13 53	13 45
	N	+0 13 5	+ 8 22					13 45	13 51	13 48	13.39				13.38	13 40
	O	+0 41 2	− 4 39					14 54	14.48	14.51	14 38				14 44	14 33
	P=R	+0 47 2	− 0 18		13 92	14 57		14 76	14.68	14 48	14.45	14 13	14 51		14 65	14.52
	Q	+0 50.8	+ 1 43		13 82	14 48			14 66	14.32	14 31	14 02	14 42			14 50
	R=P	+0 47.2	− 0 18		13 92	14 57		14.76	14 68	14 48	14 45	14 13	14 51		14 65	14 52
	S	+0 48.8	− 0 54		14 78	15 14			15 30	15.07	15.07	15 04	15 07			15 11
	T	+0 47.4	+ 1 5		14 58	14 99			14 98	14 85	14 85	14 83	14 92			14 80
	U	+0 44.3	− 0 50		15 23	15 35			15 47	15.35	15.35	15.52	15 27			15 27

Northern Regions.

R Vulpeculae $20^h\ 59^m\ 56^s + 23^\circ\ 25'.5$ (1900).

Hagen	Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		m s	$'$ $''$													
1		−2 1.2	−29 38													
2		−0 52.2	+10 35													
3		+0 51 4	−13 20													
5		+0 42.3	−20 5													
6		−0 36 0	−13 56													
7		−0 27.4	−23 58													
9		+0 16.4	−14 0													
11		−0 3 4	−10 36													
30		+0 53.6	−13 59													
23	A	+0 48 2	+ 4 54	10 51	10 57	10.62	10.70	10 60	10 62	10.60	10 60					
24	B	+0 33 8	+ 5 9	10 39	10.43	10.36	10 46	10 44	10.72	10 47	10 47					
25	C	−0 18 2	+ 4 11	10 83	10 54	10 69	10 56	10 72	10 60	10 66	10 66					
26	D	+1 1.9	+ 4 2	11 02	10.82	11 06	11 01	11.00	10 82	10 96	10 96					
29	E	−0 15 2	− 6 56	10 72	11.09	——	10 75	——	——	10.85	10 85					
	F	+0 35 1	+ 2 2				12.40		12 83	12 62	12.60			12.47		12 73
	G	+0 27 0	− 9 13				12.45		12.71	12 58	12.57			12 52		12 62
	H	+0 23.6	− 8 43				12 56		13 03	12 80	12 78			12.64		12 92
	J	+0 44.2	− 9 50				12 77		13 13	12 95	12.94			12 86		13 02
	K	+0 56 8	− 4 16				12 92		——	12.92	13 02			13 02		——
	L	+0 38 2	− 4 56					13 89	14 05	13 97	13 85				13 80	13.90
	M	+0 17 5	− 3 30					14.10	14 37	14 24	14 10				14.00	14 20
	N	+0 23.8	− 3 55					14 30	14 98	14 64	14 49				14 20	14.78
	O=R	+0 25 0	+ 0 30		14 52	14 81		14 68	15 02	14 76	14 72	14 79	14.73		14 56	14.82
	P=U	+0 31 9	− 3 36		14.68	15 04		14 82	14 91	14 86	14 84	14 96	14 96		14.70	14.72
	Q	+0 21 7	+ 1 18		14 39	14 72			14 91	14 67	14.67	14 65	14.65			14.72
	R=O	+0 25 0	+ 0 30		14.52	14 81		14 68	15.02	14 76	14.72	14.79	14 73		14 56	14 82
	S	+0 28 2	− 0 21		15 05	15 46			15 00	15 17	15 17	15 36	15.37			14 80
	T	+0 30 6	− 2 48		15 19	15 43			15.28	15 30	15 30	15 51	15 34			15.07
	U=P	+0 31 9	− 3 36		14.68	15 04		14 82	14 91	14 86	14 84	14 96	14 96		14.70	14 72

Northern Regions.

R Lacertae $22^h\ 38^m\ 50^s + 41^\circ\ 50'.9$ (1900)

Hagen	Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Yerk.	Lick	McCormick A	McCormick B	McCormick C	Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick A	McCormick B	McCormick C
		$m\ s$	$'\ ''$													
2		−1 7.0	+ 1 40													
5		−1 40.8	+ 2 48													
6		−2 15.6	+13 50													
7		+1 14.7	−18 30													
8		+1 40.4	+12 22													
9		+0 35.5	− 1 4													
11		+2 4.2	−11 40													
14		+0 16.8	+ 7 59													
15		+0 22.1	+ 3 28													
19		+2 6.6	− 3 21													
45	A	+1 19.0	+ 9 47	11.76	11.86	11.83	12.03	11.78	11.78	11.84	11.84					
51	B	+0 23.7	− 3 44	12.35	12.41	12.26	12.33	12.30	12.38	12.34	12.34					
52	C	+0 35.4	−11 41	12.39	12.35	12.29	12.32	12.37	12.39	12.35	12.35					
54	D	+1 25.5	+ 5 20	12.50	12.36	12.53	12.38	12.58	12.54	12.48	12.48					
56	E	−0 12.4	+ 3 1	12.40	12.42	12.48	12.33	12.39	12.32	12.39	12.39					
	F	+0 41.6	+ 2 4				13.02		13.22	13.12	13.12			13.05		13.18
	G	+0 49.1	+ 3 2				13.08		13.30	13.19	13.18			13.11		13.25
	H	+1 18.7	+ 1 17				13.30		13.37	13.34	13.33			13.34		13.32
	J	+0 57.0	− 3 46				13.48		13.46	13.47	13.47			13.53		13.41
	K	+1 28.4	− 2 37				13.55		13.57	13.56	13.56			13.61		13.51
	L	+1 3.6	+ 5 44					13.88	13.94	13.91	13.84				13.83	13.86
	M	+0 50.1	+ 6 49					14.68	14.34	14.51	14.43				14.61	14.25
	N	+0 22.1	− 3 25					14.79	14.04	14.42	14.34				14.72	13.96
	O	+1 16.3	+ 8 36					14.94	14.67	14.80	14.71				14.86	14.56
	P	+1 21.3	+ 8 54					15.83	15.11	15.47	15.36				15.73	14.98
	Q	+0 50.9	+ 0 59		14.25	14.57			14.57	14.46	14.47	14.38	14.53			14.47
	R	+0 54.9	− 1 44		14.34	14.44			14.59	14.46	14.46	14.48	14.40			14.49
	S	+1 7.6	+ 0 49		14.98	14.93			15.20	15.04	15.04	15.17	14.88			15.07
	T	+1 5.9	+ 1 19		14.85	14.83			15.07	14.88	14.91	15.03	14.78			14.94
	U	+0 55.5	+ 0 23		15.83	15.74			——	15.78	15.84	16.08	15.68			——

Northern Regions.

R Pegasi 23 1 38 + 10 0.2 (1900).

Hagen	Star	Δ α	Δ δ	Harv.	Yerk.	Lick	McCormick			Obs'd Mean	Adj'd Mean	Yerk.	Lick	McCormick		
							A	B	C					A	B	C
		m s	′ ″													
2		−1 13.5	− 5 42													
3		+1 39.4	+ 2 1													
9		+0 17.5	− 9 50													
13		−0 11.0	+ 5 4													
15		−0 43.8	−11 29													
17	A	−0 31.5	− 4 49	11.48	11.74	11.57	11.66	11.74	11.64	11.64	11.61					
19	B	+0 9.1	+14 6	12.10	11.97	12.01	11.97	12.11	11.83	12.00	12.00					
20	C	+0 42.4	− 0 37	11.93	12.06	12.03	11.98	11.95	11.90	11.98	11.98					
21	D	+0 20.5	− 4 39	11.88	11.77	11.88	11.77	11.77	11.94	11.84	11.84					
23	E	+0 53.8	+11 38	12.29	12.13	12.18	12.29	12.09	12.37	12.22	12.22					
	F	+0 10.6	+ 4 50				13.47		13.98	13.72	13.72			13.54		13.89
	G	+0 22.7	+ 4 45				13.51		13.77	13.64	13.64			13.58		13.69
	H	+0 14.8	− 1 21				13.52		13.90	13.71	13.70			13.59		13.81
	J	+0 32.2	− 7 55				13.59		13.72	13.66	13.65			13.66		13.64
	K	+0 58.0	− 3 2				13.74		13.97	13.86	13.85			13 82		13.88
	L	+0 9.4	+ 4 0					14.07	14.21	14.14	14.06				14.01	14.11
	M	+0 38.8	+ 2 1					14.61	14.27	14.44	14.35				14.53	14.17
	N	+0 49.2	− 2 8					14.92	15.08	15.00	14.88				14.81	14.94
	O	+0 32.1	+ 4 44					14.98	15.20	15.09	14.97				14.89	15.05
	P	+0.37.3	+ 4 32					15.22	15.25	15.24	15.11				15.12	15.10
	Q	+0 32.4	− 1 31		14.68	15.01			15.14	14.94	14.94	14.88	14.95			14.99
	R	+0 29.1	− 3 38		15.01	15.28			15.48	15.26	15.26	15.23	15.22			15.32
	S	+0 26.1	− 1 37		15.52	15.60			15.58	15.57	15.57	15.78	15.53			15.41
	T	+0 26.8	− 0 56		15 02	15.30			15.40	15.24	15.24	15.24	15.24			15.24
	U	+0 15.1	+ 1 4		15.32	15.42			15.62	15.45	15.46	15.56	15.36			15.45

TABLE XII.

Southern Regions.

S Ceti $0^h\ 18^m\ 58^s\ -9^\circ\ 53'.0$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	+0 0.1	− 3 53	12 32	12.35	12.32	12.37	12.34
B	−1 1.5	− 2 44	12 50	12.47	12.51	12.39	12.47
C	+0 2 1	+10 10	12.67	12 63	12.52	12.62	12 61
D	+0 35 8	+ 9 54	12 64	12 74	12.75	12 92	12.76
E	−0 48 3	− 6 19	12 91	12 84	12.92	12.73	12.85
F	−0 3.0	+ 5 34			13.75		13 80
G	+0 46.1	+ 7 56			14.02		14.08
H	−0 16.9	+ 2 8			14.10		14.16
J	+0 31.0	− 0 11			14.25		14.32
K	+0 46.4	+ 4 6			14.26		14.33
L	+0 11.2	+16 5				13.43	13.41
M	+0 38.9	+13 5				14.40	14.35
N	+0 40.5	+14 50				14.60	14.54
O	+0 36.5	+15 28				14.65	14.59
P	+0 29.9	+ 3 4				15.52	15.44
Q	−0 2.6	− 2 4		14.96			14.92
R	−0 5 8	− 4 5		15.32			15.27
S	+0 2.2	− 5 0		15.55			15.50
T	+0 12.7	− 3 48		15.57			15.51
U	+0 8.1	− 0 17		15.66			15.60

R Ceti $2^h\ 20^m\ 55^s\ -0^\circ\ 37'.8$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	+0 27.4	+13 43	12.03	12.17	12.24	12.25	12.17
B	−0 22.4	+ 5 48	12.43	12.43	12.41	12.40	12 42
C	+0 16.8	+12 45	12.60	12.40	12.49	12.24	12 43
D	+0 51 8	+ 3 51	12.62	12 78	12.64	12 68	12 68
E	+0 25.3	+11 56	12.93	12 83	12.83	13 04	12 91
F	+0 25.8	+ 1 33			14.26		14.34
G	+0 14.3	+ 9 46			14.56		14 65
H	−0 14.6	− 3 29			14.80		14 90
J	+0 18.1	+ 9 0			14.98		15 09
K	−0 13.1	− 4 26			15 00		15.11
L	+0 7.7	+14 2				14.49	14.43
M	−0 13 6	+12 45				14 50	14.44
N	−0 6 2	+12 28				14.58	14 52
O	+0 38 7	+ 3 29				15 80	15 70
P	+1 21 7	+ 7 33				15 84	15 74
Q	+0 13 2	+13 0		15.74			15 68
R	+0 11 9	+13 25		15 88			15 82
S	+0 4 0	+10 28		15 90			15 84
T	−0 20 3	+ 5 0		16 09			16 02
U	+0 17.4	+11 7		16 16			16 09

SOUTHERN REGIONS.

S Orionis $5^h\ 24^m\ 5^s$ $-4^\circ\ 46'.4$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	$^m\ ^s$	$'\ ''$					
A	−0 29.2	+7 56	11.94	11.76	12.05	11.88	11 91
B	+0 14.7	−1 12	11.56	11.66	11.62	11.76	11 65
C	+0 27.4	−7 44	11.54	11.64	11.66	11.57	11 60
D	+0 3.6	+3 5	12.12	12.06	12.00	12.12	12 08
E	+0 57.9	−4 41	11.98	12.03	11.79	11.82	11 90
F	−0 12.2	+1 48			13.25		13.31
G	+0 7.3	+8 45			13.30		13.36
H	+0 27.8	+3 18			13.36		13.43
J	+0 27.9	+0 12			13.36		13.43
K	+0 3.0	−6 45			13.44		13.51
L	+1 13.0	−0 47				14.94	14.85
M	+0 50.6	−1 16				14.99	14.90
N	+0 47.4	−1 17				15.08	14.99
O	+0 50.2	−4 3				15.20	15.10
P	+0 52.9	−4 30				15.33	15.23
Q	−0 23.9	+4 11		14.49			14.44
R	−0 38.8	+2 30		15.27			15.21
S	−0 20.9	+6 5		15.33			15.26
T	−0 32.5	+5 30		15.40			15.33
U	−0 16.8	+6 4		15.43			15.36

U Puppis $7^h\ 56^m\ 8^s$ $-12^\circ\ 33'.8$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	$^m\ ^s$	$'\ ''$					
A	−0 25.6	+3 24	11.43	11.48	11.22	11.45	11.40
B	−0 41.7	−3 56					
C	−0 3.2	−4 30	11.76	11.65	11.68	11.60	11.67
D	+0 21.4	−4 16	11.13	11.34	11.28	11.40	11.29
E	+0 6.6	−8 25	11.36	11.21	11.49	11.22	11.32
F	+0 0.4	−3 39			13.26		13.34
G	+0 19.4	+0 44			13.28		13.36
H	−0 11.1	−3 42			13.43		13.52
J	−0 21.4	−0 0			13.53		13.62
K	+0 23.9	−0 47			13.66		13.76
L	+0 35.0	−2 25				13.99	13.91
M	+0 21.1	−2 29				14.32	14.24
N	+0 22.4	−0 33				14.42	14.31
O	+0 29.3	−1 3				14.48	14.39
P	+0 32.7	−3 9				14.54	14.45
Q	+0 4.7	−6 26		14.97			14.90
R	+0 14.1	−6 3		15.04			14.97
S	+0 13.1	−4 34		15.11			15.03
T	+0 18.0	−5 53		15.48			15.40
U	+0 16.2	−5 8		15.65			15.57

Southern Regions.

T Hydrae 8 50 48 −8 45.6 (1900)

Star	Δ α	Δ δ	Harv.	Lick	McCormick		Adj'd Magn.
					A	B	
	m s	′ ″					
A	+0 32.2	−0 6	11.42	11.66	11.69	11.57	11 58
B	−0 28.1	+9 28	11.91	11.94	11.89	12.06	11 95
C	−0 38.4	−1 29	12.29	12.10	12.10	12.17	12 16
D	−0 20.9	−3 8	12.13	12.12	12.02	12.12	12 10
E	+0 45.4	+2 37	12.16	12.09	12.20	12.00	12 11
F	−0 25.8	−2 12			13.61		13.68
G	+0 31.7	−5 17			13.70		13.77
H	+0 14.7	−6 54			13.87		13.95
J	−0 5.8	−6 6			13.91		13.99
K	+0 24.5	+3 51			14.15		14.24
L	+0 43.9	+5 53				15.02	14.93
M	+0 41.0	+1 42				15.25	15.16
N	+0 38.4	+5 49				15.47	15.37
O	+0 42.9	+3 9				15.48	15.38
P	+0 50.0	+5 51				15.87	15.76
Q	−0 47.7	−1 51		15.07			15.01
R	−0 52.9	−2 1		15.09			15.03
S	−0 42.2	+0 57		15.44			15.38
T	−0 44.9	−0 55		15.45			15.39
U	−0 50.2	−2 32		16.00			15.93

T Virginis 12 9 29 −5 28.8 (1900)

Star	Δ α	Δ δ	Harv.	Lick	McCormick		Adj'd Magn.
					A	B	
	m s	′ ″					
A	+0 46.7	−13 53	11.62	11.75	11.64	11.44	11.61
B	+0 37.9	+ 3 16	11.46	11.57	11.79	11.55	11 59
C	+0 17.8	− 7 55	12.21	11.98	11.99	12.48	12.16
D	−0 11.4	−14 4	12.25	12.31	12.02	12.35	12 23
E	+0 14.2	− 6 43	12.24	12.16	12.33	11.96	12.17
F	−0 21.7	− 4 47			13.48		13 55
G	−0 31.7	− 5 38			13.53		13.60
H	+0 27.0	− 2 4			14.05		14.14
J	+0 38.1	− 1 56			14.13		14.22
K	+0 21.0	+ 3 18			14.20		14.30
L	+0 49.9	+ 8 19				13.81	13.76
M	+0 0.5	+ 9 4				14.50	14.43
N	+0 5.9	+ 6 33				14.72	14 64
O	+0 35 2	+ 8 49				14.87	14 79
P	+0 46.7	+ 9 25				15.47	15.37
Q	+0 35.6	+ 5 14		15.26			15.20
R	+0 39.2	+ 2 2		15.48			15 41
S	+0 36 9	+ 4 33		15 55			15 48
T	+0 3 3	− 7 12		15 64			15 57
U	+0 30.6	+ 3 36		15 65			15 58

Southern Regions.

S Virginis 13h 27m 47s −6° 40.8′ (1900)

Star	Δα	Δδ	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	+0 7.7	+11 16	12.06	12.22	12.11	12.21	12 15
B	−0 43.3	+ 6 22	11.97	12.13	12.19	12 09	12 10
C	−0 55.3	+13 30	12.31	12.38	12.37	12.18	12 31
D	−0 49.5	+ 8 33	12.92	12.71	12.66	12.77	12 76
E	−0 14.8	+ 4 5	12.95	12.78	12 89	12 95	12 89
F	+0 23.2	+ 3 1			13.70		13.75
G	−0 26.4	+ 1 20			13.85		13.91
H	+0 37.1	+ 7 32			14.03		14.10
J	+1 15.7	+ 0 4			14.11		14.18
K	+1 26.3	+ 1 30			14.36		14.44
L	+0 50.5	− 3 32				14.89	14.82
M	+0 38.7	− 4 30				15.36	15.25
N	+0 43.0	− 4 50				15.70	15.60
O	+0 51.1	−10 59				15.81	15.71
P	+0 37.5	−10 0				15.84	15.74
Q	+0 11.0	+ 0 18		15.31			15.26
R	+0 9.8	− 0 57		15.53			15.47
S	−0 3.6	+13 33		15.83			15.77
T	−0 4.1	+15 22		16.02			15.95
U	−0 9.6	+ 0 29		16.17			16.10

RR Librae 15h 50m 39s −18° 0.7′ (1900)

Star	Δα	Δδ	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	−1 3.9	−3 27	11.61	11.62	11.54	11.59	11 59
B	−0 40.4	−1 4	11.58	11.67	11.64	11.59	11 62
C	−0 3.6	+8 26	11.51	11.62	11.60	11.65	11 60
D	−0 56.8	−5 40	11.76	11.44	11.63	11.67	11 62
E	−0 14.0	+6 52	11.59	11.70	11.64	11.54	11 62
F	+0 48.0	−6 59			12.94		13.00
G	+0 13.7	−0 31			13.22		13.29
H	−0 5.2	−8 24			13.68		13.77
J	+1 3.5	+0 5			13.83		13.93
K	+0 52.9	+4 10			14.26		14.38
L	+0 53.2	−5 32				14.32	14.24
M	+0 36.4	−4 30				14.59	14.50
N	+0 48.4	−3 55				15.08	14.98
O	+0 59.2	−4 48				15.30	15.19
P	+0 38.9	−3 31				15.39	15.28
Q	−0 10.4	−0 40		14.04			14.00
R	−0 10.3	−1 55		14.34			14.29
S	−0 4.8	−1 55		14.50			14.45
T	−0 13.4	+0 57		15.02			14.96
U	−0 3.7	+1 28		15.34			15.27

Southern Regions.

R and S Scorpii $16^h\ 11^m\ 42^s - 22^\circ\ 40'.4$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick	McCormick		Adj'd Magn.
					A	B	
	m s	′ ″					
A	+0 29.8	−3 21	11.81	11.66	11.91	11.56	11.74
B	+0 40.6	+5 58	12.00	11.96	12.06	12.17	12.05
C	+0 52.2	−3 15	12.09	12.09	11.92	12.01	12.03
D	−0 14.9	+4 20	12.34	12.26	12.18	12.18	12.24
E	+0 48.4	+1 30	12.29	12.55	12.45	12.59	12.47
F	+0 24.0	+0 13			13.21		13.26
G	+0 39.2	−2 45			13.28		13.33
H	+0 27.1	+1 7			13.32		13.37
J	+0 19.1	−4 52			13.47		13.53
K	+0 48.0	−1 24			13.81		13.88
L	+0 15.3	−3 40				14.52	14.45
M	+0 10.8	−4 27				14.57	14.50
N	+0 21.1	−4 44				14.87	14.79
O	+0 11.1	−4 51				14.93	14.85
P	+0 11.5	−3 37				15.65	15.55
Q	+0 17.2	−1 31		14.83			14.78
R	+0 12.9	−1 53		15.09			15.03
S	+0 19.6	−0 18		15.47			15.41
T	+0 4.7	−1 47		15.52			15.46
U	+0 4.1	−2 18		15.76			15.69

Z Sagittarii $19^h\ 13^m\ 47^s - 21^\circ\ 6'.6$ (1900)

Star	$\Delta\alpha$	$\Delta\delta$	Harv.	Lick.	McCormick		Adj'd Magn.
					A	B	
	m s	′ ″					
A	−0 20.2	−5 10	10.59	10.59	10.59	10.53	10.58
B	−0 45.6	−2 1	10.93	10.93	10.96	10.93	10.94
C	−0 55.3	−5 33	10.78	11.01	11.11	10.92	10.96
D	−0 16.8	−2 8	11.51	11.46	11.34	11.50	11.45
E	+0 27.4	+5 6	11.63	11.47	11.44	11.56	11.52
F	+0 37.5	−2 5			12.36		12.42
G	+0 19.0	−7 14			12.86		12.94
H	+0 33.7	−5 25			12.87		12.95
J	+0 43.4	−1 18			12.98		13.06
K	+0 42.2	+1 4			13.74		13.96
L	+0 29.4	−2 36				14.13	14.04
M	+0 27.4	−1 23				14.14	14.05
N	+0 40.4	−2 33				14.15	14.06
O	+0 32.7	−6 2				14.42	14.32
P	+0 58.8	−1 28				14.52	14.42
Q	+0 13.4	−4 36		14.39			14.33
R	+0 15.2	−5 33		14.66			14.59
S	+0 8.8	−4 37		14.67			14.60
T	+0 5.8	−4 44		15.07			15.00
U	+0 12.0	−4 59		15.32			15.24

Southern Regions.

V Capricorni 21h 1m 47s −24° 19′.3 (1900)

Star	Δα	Δδ	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	+0 21.1	− 7 7	10.58	10.80	10.74	10 79	10.73
B	+0 43.1	− 2 18	11 20	11 24	11 20	11 22	11 22
C	−0 13.8	−23 31	11 24	11 17	11 24	11 17	11.20
D	+0 47.8	+ 7 48	11 48	11 27	11 33	11 33	11 35
E	+0 12.3	−20 29	11 33	11 35	11 30	11 32	11 32
F	+1 10.1	+ 0 5			13 32		13.41
G	+1 3.2	+ 3 13			13 48		13.58
H	+0 48.2	− 0 14			13 59		13.70
J	+0 55 8	+ 0 19			13 82		13.94
K	+0 34.1	+ 4 49			13 82		13 94
L	+0 35 4	− 3 9				13.92	13.84
M	+0 23.2	− 2 48				14.31	14.22
N	+0 36.5	− 6 46				14.75	14.65
O	+0 54 5	−15 30				14.80	14.69
P	+0 35.2	− 6 7				15 60	15.47
Q	+0 32.8	− 0 40		14.39			14 33
R	+0 30.2	+ 2 57		14.52			14 46
S	+1 2.3	+ 1 46		14.55			14.49
T	+0 45 6	− 1 59		14 64			14.58
U	+0 55 9	− 2 23		14.84			14 67

S Aquarii 22h 51m 45s −20° 52′.6 (1900)

Star	Δα	Δδ	Harv.	Lick	McCormick A	McCormick B	Adj'd Magn.
	m s	′ ″					
A	−0 50 7	+15 59	11 03	11 03	11 11	11.09	11 06
B	+0 34 3	−10 58	11 10	11.04	10.92	11.27	11 08
C	+0 36 8	+12 9	11 91	11 99	11 93	11.78	11 90
D	−0 22.1	−12 25	11 75	11 80	11 88	11 78	11 80
E	−0 20 4	−10 32	12 01	11.93	11 97	11.89	11.95
F	+0 42.3	− 7 48			13.38		13.46
G	−0 41.5	− 6 46			13.86		13.96
H	+0 29 0	− 8 2			14.00		14.11
J	−0 17 2	− 5 50			14.14		14.25
K	−0 9.1	− 6 27			14.24		14.36
L	+0 20.2	+ 0 12				13.65	13.59
M	+0 46.6	+ 0 25				14.40	14.32
N	+0 55 2	+ 2 56				14.78	14.69
O	+0 32.5	+ 8 12				14.92	14.82
P	+0 51 8	+ 7 54				15.09	15.02
Q	−0 12.1	− 1 1		14.47			14.42
R	+0 4.5	+ 4 30		14.79			14.73
S	−0 6.4	+ 4 41		15.51			15 44
T	+0 6.7	+ 6 28		15 71			15.63
U	+0 10.0	+ 5 14		15.77			15.69

In Table XIII are given in the second column the mean magnitudes of the five standard stars of twelfth magnitude. In the third column is the mean of the observed values of the sixteenth magnitude. In the three following columns are found the differences from this mean for Yerkes, Lick and McCormick. It is seen that Parkhurst on the average is 0.21 magnitudes brighter than the mean, that Aitken is 0.07 fainter, and the McCormick Observatory 0.14 magnitudes fainter than the mean. In the sixth, seventh and

TABLE XIII.

Region	Mean Magn.		Diff. in Magn. from Mean			Scale		
	12th	16th	Yerkes	Lick	McC.	Yerkes	Lick	McC.
U Cassiopeiae . . .	12.06	15.06	−.21	+.05	+.17	0.930	1.016	1.057
S Piscium	11.80	15.19	−.22	+.04	+.18	.935	1.012	1.053
S Cassiopeiae	11.77	15.19	−.09	+.03	+.08	.974	1.009	1.023
U Arietis	13.03	15.23	−.12	+.03	+.07	.945	1.014	1.032
R Persei	11.61	15.20	−.24	+.08		.934	1.022	
V Tauri	12.45	15.09	−.31	+.08	+.09	.883	1.031	1.034
V Aurigae	12.30	14.80	−.43	+.20	+.23	.828	1.080	1.092
R Geminorum	11.95	15.16	−.35	+.22	+.13	.891	1.068	1.041
V Cancri	12.05	15.18	−.28	−.06	+.36	.910	0.981	1.115
R Leo. Minoris . . .	12.85	14.95	−.04	.00	+.07	.981	1.000	1 033
W Leonis	12.59	15.65	−.24	−.04	+.27	.922	0.987	1.088
T Ursae Majoris . .	13.00	15.46	−.14	+.05	+.06	.943	1.021	1 024
U Virginis	12.09	15.30	−.21	+.10	+.09	.934	1.031	1.028
S Bootis	12.60	15.16	+.01	−.10	+.08	1 004	0 960	1.031
R Camelop.	12.26	15.33	−.03	+.04		.990	1.013	
R Serpentis	11.74	14.88	−.20	+.04	+.10	.936	1 013	1.032
W Herculis	11.72	15.78	−.41	+.33	+.10	.899	1.082	1.025
S Herculis	11.60	15.53	−.35	+.14	+.22	.911	1.036	1.056
R Aquilae	11.78	15.59	−.25	+.12		.934	1 032	
χ Cygni	11.11	14.81	−.34	+.10	+.21	.908	1.027	1.057
R Vulpeculae	10.69	14.95	−.19	+.14	+.07	.955	1 033	1.016
R Lacertae	12.28	14.92	−.07	−.02	+.15	.973	0 992	1 057
R Pegasi	11.94	15.29	−.18	+.03	+.15	.946	1.009	1.045
Average			−.213	+.070	+.144	0 933	1.020	1 047

eighth columns are found the values of the individual scales compared with the mean scale for each region observed. It is seen that in any given column the values are not constant; for instance, in the Yerkes column the values range from 0.828 to 1.004. These changes are due to differences in the adjustment of photometer, differences in seeing, personal equation, etc. The mean values are given at the bottoms of the columns. The reciprocal of these quantities is the amount that the scales of the three observatories must be changed to bring the magnitudes into accord with the mean of all.

By taking the stars of fourteenth magnitude observed in common by Simpson and

Reed and by Mitchell and Alden, and those of the fifteenth magnitude common to Curtis and to Mitchell and Alden, it is readily possible to determine the corrections to scale so that all observers may be brought to a common scale.

The values of the corrections to the observed scale determined are: Parkhurst +.072, Aitken −.019, Simpson and Reed +.044, Curtis −.029, Mitchell and Alden −.045. The plus sign means that the *observed* magnitudes are too small and must be increased to be on the mean scale. The results from the McCormick series are quite in keeping with the conclusions already drawn regarding personal equations (see p. 276). Simpson and Reed used a fairly large aperture for forming the artificial star and also used a compromise focus so as to observe the images of the artificial star reflected from both front and back surfaces of the plane glass diagonal. Curtis employed the same aperture, but focused so as to observe the image from the front surface only. Mitchell and Alden differed from Curtis by utilizing a smaller aperture. For the larger aperture and compromise focus the range between the standards of twelfth magnitude and the faint stars was not sufficiently extended compared with the mean, while the smaller aperture used by Mitchell and Alden gave an extension of magnitude greater than that of Curtis.

The above values show that the scale of Parkhurst's measures with the forty-inch refractor is 7.2 percent less extended than the mean which includes his own measures. The Yerkes scale is 9.2 percent less than Aitken and 12.2 percent less than Mitchell and Alden, or approximately eleven percent less extended than the mean of Lick and McCormick. Nijland, *Hemel en Dampkring*, **14**, 65, 1916, has examined into the differences in the visual scale of Harvard and that of Parkhurst in his *Research in Stellar Photometry*, 1906, and found that Harvard and Parkhurst agree at the ninth magnitude but differ 0.76 magnitudes at Harvard mean magnitude 13.09. According to Nijland the difference in scale is twenty-two percent, the Parkhurst magnitudes making the stars brighter. In *Groningen Publications*, **27**, 45, 1917, van Rhijn comes to the conclusion that the Parkhurst scale is in error, and adds that "it certainly would be very desirable that some astronomer should make an independent determination of the brightness of the faint stars in some regions observed as well by Parkhurst as by Pickering." Mitchell and Alden have already completed the determination of the magnitudes of faint comparison stars in many regions of long period variables, in addition to those of the Rumford regions here discussed. Although the results are unpublished, Mitchell and Alden in general agree fairly closely with the Harvard scale but differ systematically from Parkhurst, their magnitudes being fainter than his.

Attention should again be called to the fact that Parkhurst independently has determined the magnitudes of the standard stars of twelfth magnitude of the Rumford series

by using the wedge photometer on his own six-inch reflector and on the twelve-inch refractor of Yerkes Observatory. The magnitudes derived are approximately seven-tenths of a magnitude brighter than the values of Pickering, the systematic difference taking place in measuring from the ninth to the twelfth magnitude with the twelve-inch refractor. This difference in scale is the same as found by Nijland. One is therefore forced to the conclusion along with Kapteyn, Seares and van Rhijn[1] that Parkhurst's visual scale gives magnitudes that are too bright. The fault appears to be mainly in his measures with the twelve-inch refractor, and the cause is probably to be found in the fact that for some reason the calibration curve investigated with such care in the laboratory does not fit the magnitudes derived by the twelve-inch refractor.

An approximate value of the scales of magnitudes for each of the series of observations may also be obtained from the measures of the standards of twelfth magnitude only by comparing the range of magnitudes obtained by the different observers within these stars themselves. Such a comparison will give not only the relative scales of the different observers with respect to the mean, but also the Harvard scale with respect to this mean. The method of procedure is as follows: In the field of U Cassiopeiae the Harvard magnitudes of the five standard stars A to E are: A=12.24, B=11.48, C=12.12, D=12.07, E=12.40, with the mean value of 12.06. The differences of each star from the mean are .18, .58, .06, .01, .34, and the sum of these five differences is 1.17. This amount represents the sum of the ranges of the five stars with respect to the mean, and will give a number which will depend on the scale of magnitudes involved, but also on the accidental errors of measurement. Measurements of a large number of stars should free these values fairly well from accidental errors of measurement, so that the average should then depend almost entirely on the scale of magnitude used. If the results are now referred to the means of the observations by Parkhurst, Aitken, Mitchell and Alden using three separate telescopes, the values are derived as given in the second line of Table XIV. In the first line are given for reference the corrections already found to reduce each observer to the mean adopted scale.

TABLE XIV.

Scale Corrections	Harvard	Parkhurst	Aitken	Mitchell and Alden	Curtis	Simpson and Reed
Referred to Mean Scale	.....	+.072	−.019	−.045	−.029	+.044
From Twelfth Magnitude only	−.170	+.034	+.013	−.046	−.008	+.104

[1] See *Groningen Publications* 27 and 31.

In consequence of the small range of magnitude involved, no great confidence can be felt in this method of deriving the scale, and the values are given only because they afford a means of comparison with the Harvard scale. The results seem to indicate that *within the range of the stars of twelfth magnitude* the Harvard scale is too extended by approximately seventeen percent. It should be pointed out, however, that a star of twelfth magnitude is a "bright" star for an aperture of forty inches, but fairly "faint" in the twelve-inch telescope used by Professor Pickering. From what has already been said we are forced to the conclusion that the larger telescopes will not measure a range of magnitudes on bright stars sufficiently great. The seventeen percent too great range for Harvard should thus be reduced slightly, probably to fifteen percent. This does not of necessity mean that the Harvard Scale is fifteen percent too extended throughout the whole range of magnitudes, but *merely* in the faintest stars in the sequence, the stars of the twelfth and thirteenth magnitudes. Attention should be again called to the fact that Professor Pickering used a "wedge constant" for the reduction of his observation, and it is quite possible that his magnitudes are too faint only in the faintest stars of the series. One might dare to hazard a guess that the Harvard magnitude of the average star of twelfth magnitude used as a standard in the present work is too faint by two-tenths of a magnitude. If the values of the standards of twelfth magnitude are derived by photovisual or other methods, it will be a simple matter to determine new values for the faint stars of the Rumford series by applying a constant correction for each region observed, which correction will be the difference between new magnitudes and those of Professor Pickering.

That the mean scale derived herein is not far from the truth is found in the magnitudes for the faintest stars measured with the twenty-six and thirty-six-inch telescopes. The theoretical limit with the former is 16.0 magnitude, while with the latter it is nearly a magnitude fainter. The faintest star measured with the Lick telescope is in the region of R Draconis, and is of magnitude 16.87 on the mean scale adopted. The faintest star measured with the twenty-six-inch refractor is the star U in the region T Ursae Majoris with the adjusted mean magnitude of 16.14, the McCormick magnitude being 15.90. If it should turn out that the Harvard magnitudes of the twelfth magnitude standards are two-tenths of a magnitude too faint, then the faintest star measured at Lick is of approximate magnitude 16.7 and at McCormick 15.9. It is possible to see stars a few tenths of a magnitude fainter than can be measured with the wedge photometer.

Summary.

The conclusions reached from the present research are as follows:

1. The range of magnitudes photometrically determined has been extended to stars nearly at the limit of visibility of the largest refractors now existing, the thirty-six-inch Lick and forty-inch Yerkes.

2. The values for the stars of the sixteenth magnitude in the twenty-four regions north of the celestial equator are the results from three different telescopes, Yerkes, Lick and McCormick, and four different observers, Parkhurst, Aitken, Mitchell and Alden. For the twelve regions south of the equator the measures are by Aitken alone.

3. The stars of fifteenth magnitude were investigated with the McCormick twenty-six-inch refractor, north of the equator by the three observers, Curtis, Mitchell and Alden, and south of the equator by Curtis alone.

4. Stars of fourteenth magnitude were likewise measured at the McCormick Observatory, by Simpson, Reed, Mitchell and Alden north of the equator, and by Simpson and Reed south of the equator.

5. All values of fourteenth, fifteenth and sixteenth magnitudes depend on the values of the twelfth magnitude standards measured by Professor E. C. Pickering with the twelve-inch meridian photometer.

6. As the stars of twelfth magnitude serve as the zero point any errors in their determination will affect all the fainter magnitudes in any region by a constant amount.

7. Parkhurst has measured all of the twelfth magnitude standards in the regions north of the equator by means of the wedge photometer attached to the twelve-inch Yerkes refractor. His results, which are still unpublished, differ systematically from the magnitudes derived by Professor Pickering, the Parkhurst magnitudes making the stars brighter than the Pickering determinations.

8. It is highly desirable that Parkhurst should publish his values for the stars of twelfth magnitude and also complete the determination of these magnitudes by photo-visual methods.

9. When the magnitudes of the standard stars of twelfth magnitude are again determined it will be a simple matter to correct the magnitudes for the fainter stars by applying a constant correction for zero point.

10. The scale adopted is based on the mean of the observations of stars of sixteenth magnitude by the four observers, Parkhurst, Aitken, Mitchell and Alden using the Yerkes, Lick and McCormick refractors. The scale depends on the calibration of the three wedges employed, and in no way on the magnitudes of the standards of twelfth magnitude. The

scale corrections of the various observers to reduce to this mean scale are: Parkhurst +.072, Aitken −.019, Mitchell and Alden −.045, Curtis −.029, Simpson and Reed +.044.

11. That the mean scale adopted is not far from the truth is shown by the magnitudes of the faintest stars measured with the Lick and McCormick telescopes.

12. Magnitudes derived by the wedge photometer seem reliable provided that only nights of good seeing are utilized and provided that the adjustments of the photometer are carefully watched.

13. Magnitudes by the wedge photometer are probably quite as accurate as those measured with a polarizing photometer.

U CASSIOPEIAE $0^h\ 40^m.8, +47^\circ\ 43'\ (1900)$

Yerkes negative, 1901, Dec. 29. Scale, 1 mm = 14.5″

North

S PISCIUM $1^h\ 12^m.4, +8^\circ\ 21'\ (1900)$

Yerkes negative, 1905, Oct. 2. Scale, 1 mm = 19.9″

North

S CASSIOPEIAE $1^h\ 12^m.3, +72^\circ\ 5'\ (1900)$

Yerkes negative, 1902, Jan. 4. Scale, 1 mm = 19.6″

North

U ARIETIS $3^h\ 5^m.5, +14^\circ\ 25'\ (1900)$

Yerkes negative, 1905, Feb. 6. Scale, 1 mm = 20.0″

North

R PERSEI $3^h\ 23^m.7$, $+35^\circ\ 20'$ (1900)

Yerkes negative, 1902, Jan. 4. Scale, 1 mm = 19.6″

North

V TAURI $4^h\ 46^m.2$, $+17^\circ\ 22'$ (1900)

Yerkes negative, 1902, Feb. 23. Scale, 1 mm = 21.7″

North

V AURIGAE $6^h\ 16^m.5$, $+47^\circ\ 45'$ (1900)

Yerkes negative, 1903, Feb. 4. Scale, 1 mm = 21.9″

North

R GEMINORUM $7^h\ 1^m.3$, $+22^\circ\ 52'$ (1900)

Yerkes negative, 1902, March 25. Scale, 1 mm = 20.7″

North

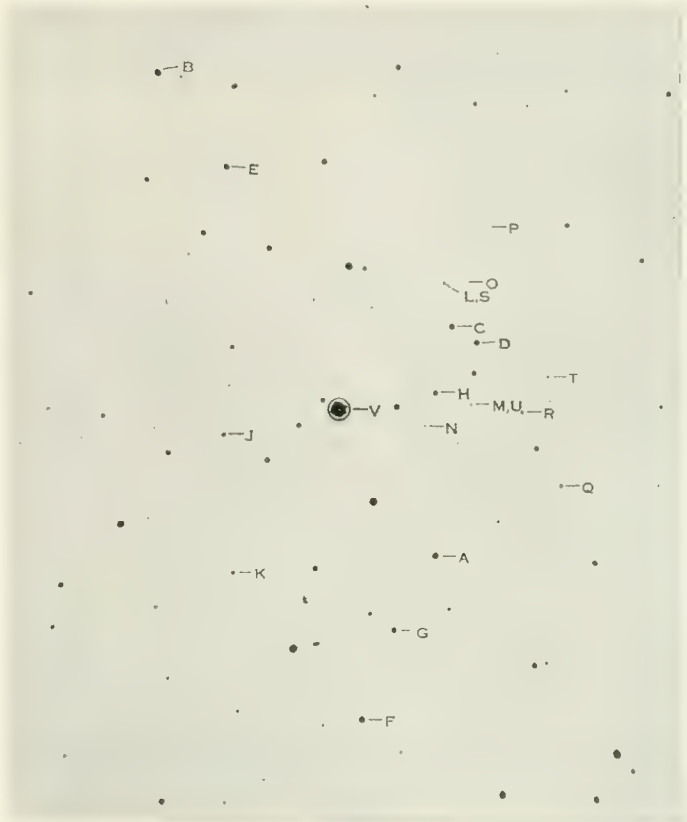
V CANCRI $8^h\ 16^m.0$, $+17^\circ\ 36'$ (1900)

Yerkes negative, 1902, March 13. Scale, 1 mm = 20.5″

North

R LEONIS MINORIS $9^h\ 39^m.6$, $+34^\circ\ 58'$ (1900)

Yerkes negative, 1916, Feb. 2. Scale, 1 mm = 21.3″



North

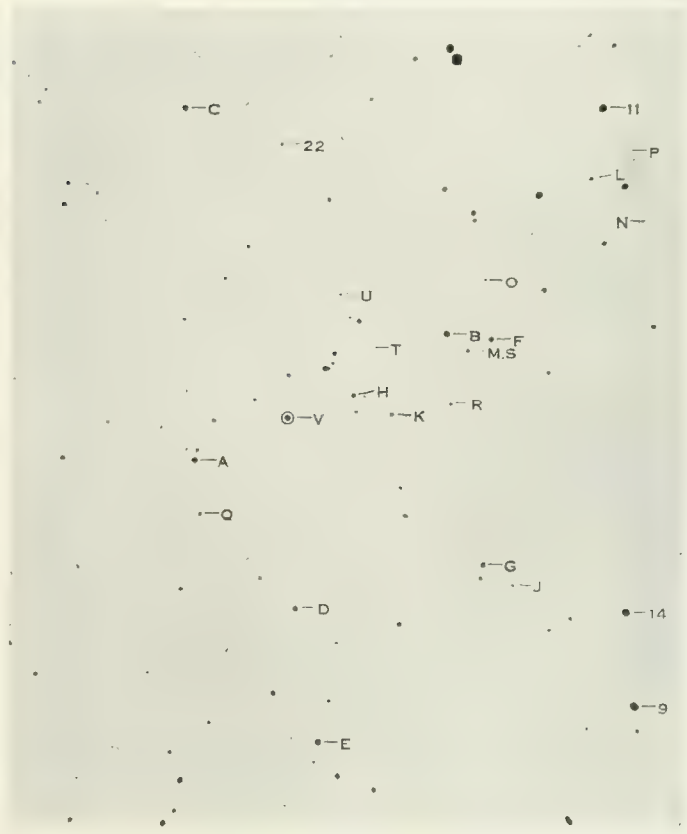
W LEONIS $10^h\ 48^m.4$, $+14^\circ\ 15'$ (1900)

Yerkes negative, 1906, April 23. Scale, 1 mm = 19.6″

North

T URSAE MAJORIS $12^h\ 31^m.8$, $+60^\circ\ 2'$ (1900)

Yerkes negative, 1902, Aug. 10. Scale, 1 mm = 20.3″



North

U VIRGINIS $12^h\ 46^m.0$, $+6^\circ\ 6'$ (1900)

Yerkes negative, 1904, June 9. Scale, 1 mm = 19.8″

North

S BOOTIS $14^h\ 19^m.5$, $+54^\circ\ 16'$ (1900)

Yerkes negative, 1902, Aug. 5. Scale, 1 mm = 19.8″

North

R CAMELOPARDALIS $14^h\ 25^m.1$, $+84^\circ\ 17'$ (1900)

Yerkes negative, 1902, Nov. 29. Scale, 1 mm = 19.9″

North

R SERPENTIS $15^h\ 46^m.1$, $+15^\circ\ 26'$ (1900)

Yerkes negative, 1904, June 18. Scale, 1 mm = 19.7″

North

W HERCULIS $16^h\ 31^m.7$, $+37^\circ\ 32'$ (1900)

Yerkes negative, 1904, June 10. Scale, 1 mm = 19.9″

North

V is double, 6″.4, 331°

R DRACONIS $16^h\ 32^m.4$, $+66^\circ\ 58'$ (1900)

Yerkes negative, 1915, Oct. 1. Scale, 1 mm = 19.6″

North

S HERCULIS $16^h\ 47^m.4$, $+15^\circ\ 7'$ (1900)

Yerkes negative, 1904, June 14. Scale 1 mm = 21.9″

North

R AQUILAE $19^h\ 1^m.6$, $+8^\circ\ 5'$ (1900)

Yerkes negative, 1904, June 18. Scale, 1 mm = 20.1″

North

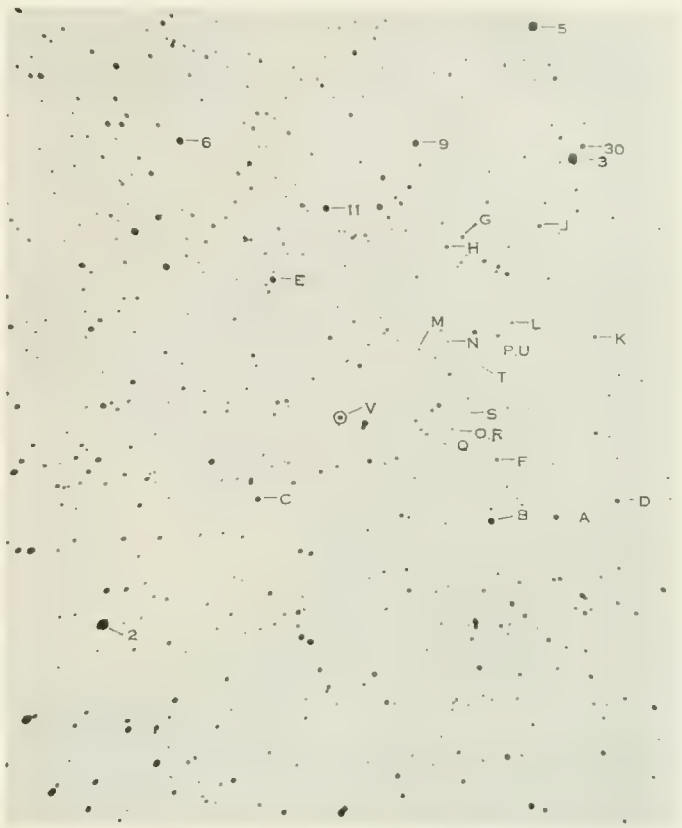
χ CYGNI $19^h\ 46^m.7$, $+32^\circ\ 40'$ (1900)

Yerkes negative, 1902, July 28. Scale, 1 mm = 19.6″

North

R VULPECULAE $20^h\ 59^m.9$, $+23^\circ\ 26'$ (1900)

Yerkes negative, 1915, Nov. 2. Scale, 1 mm = 23.0″



North

R PEGASI $23^h\ 1^m.6$, $+10^\circ\ 0'$ (1900)

Yerkes negative, 1901, Dec. 29. Scale, 1 mm = 17.7″

North

R LACERTAE $22^h\ 38^m.8$, $+41^\circ\ 51'$ (1900)

Yerkes negative, 1901, Nov. 30. Scale, 1 mm = 21.5″

North

S CETI $0^h\ 19.0^m$, $-9^\circ\ 53'$ (1900)

Yerkes negative, 1907, Oct. 6. Scale, 1 mm = 20.3″

North

R CETI $2^h\ 20.9^m$, $-0^\circ\ 38'$ (1900)

Yerkes negative, 1907, Nov. 26. Scale, 1 mm = 20.4″

North

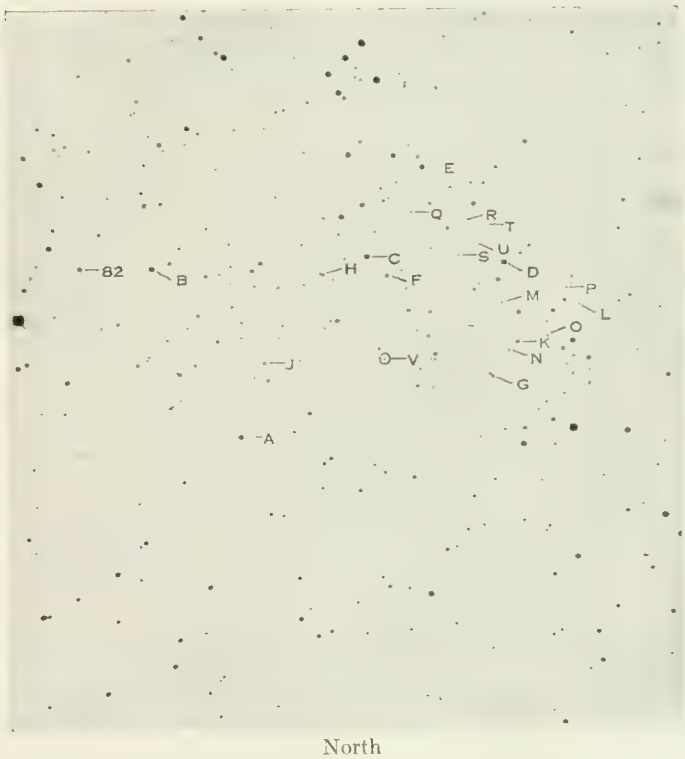
S ORIONIS $5^h\ 24.1^m$, $-4^\circ\ 46'$ (1900)

Yerkes negative, 1911, March 18. Scale, 1 mm = 21.6″

North

U PUPPIS $7^h\ 56.1^m$, $-12^\circ\ 34'$ (1900)

Yerkes negative, 1908, April 3. Scale, 1 mm = 19.7″



North

T HYDRAE $8^h\ 50^m.8,\ -8^\circ\ 46'$ (1900)

Yerkes negative, 1908, April 3. Scale, 1 mm = 19.5″

North

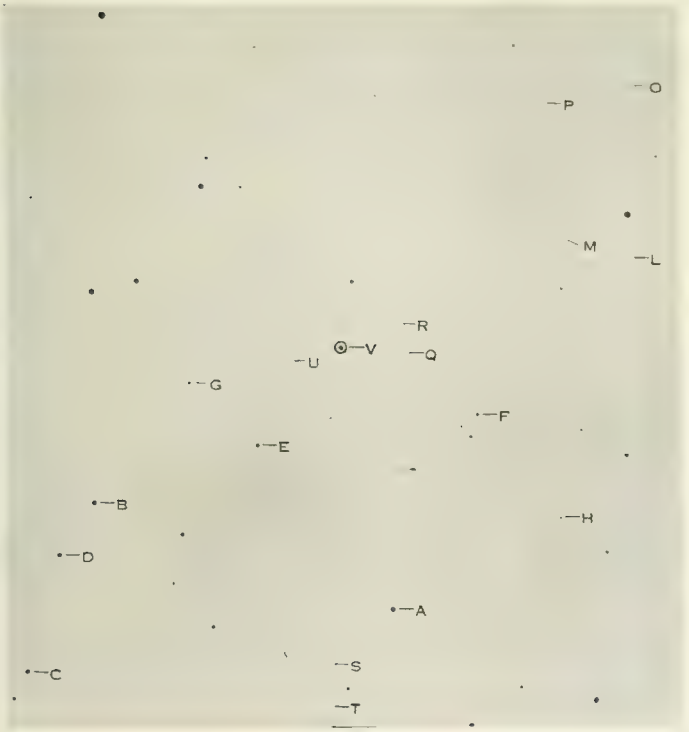
T VIRGINIS $12^h\ 9^m.5,\ -5^\circ\ 29'$ (1900)

Yerkes negative, 1908, Jan. 8. Scale, 1 mm = 20.3″

North

S VIRGINIS $13^h\ 27^m.8,\ -6^\circ\ 41'$ (1900)

Yerkes negative, 1919, April 28. Scale, 1 mm = 19.4″



North

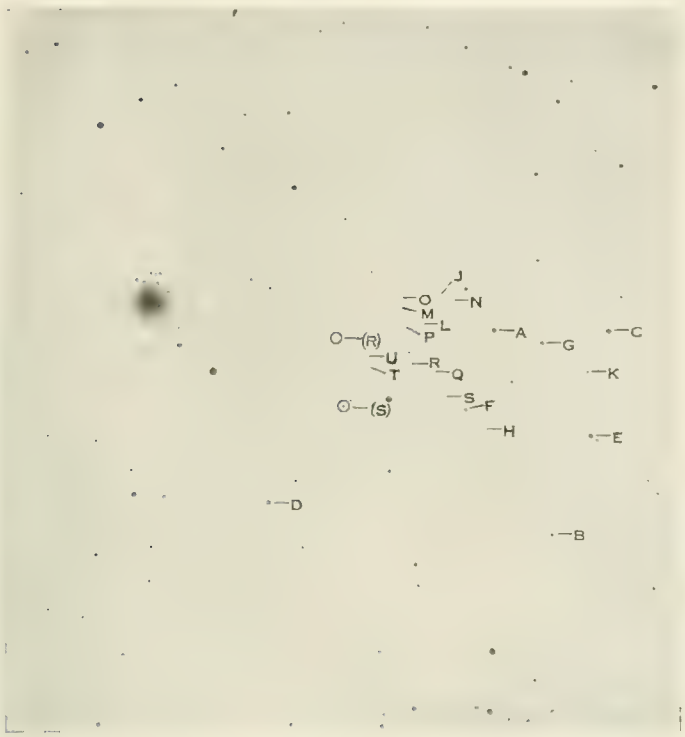
RR LIBRAE $15^h\ 50^m.6,\ -18^\circ\ 1'$ (1900)

Yerkes negative, 1909, July 16. Scale, 1 mm = 19.7″

North

R and S SCORPII $16^h\ 11^m.7$, $-22^\circ\ 40'$ (1900)

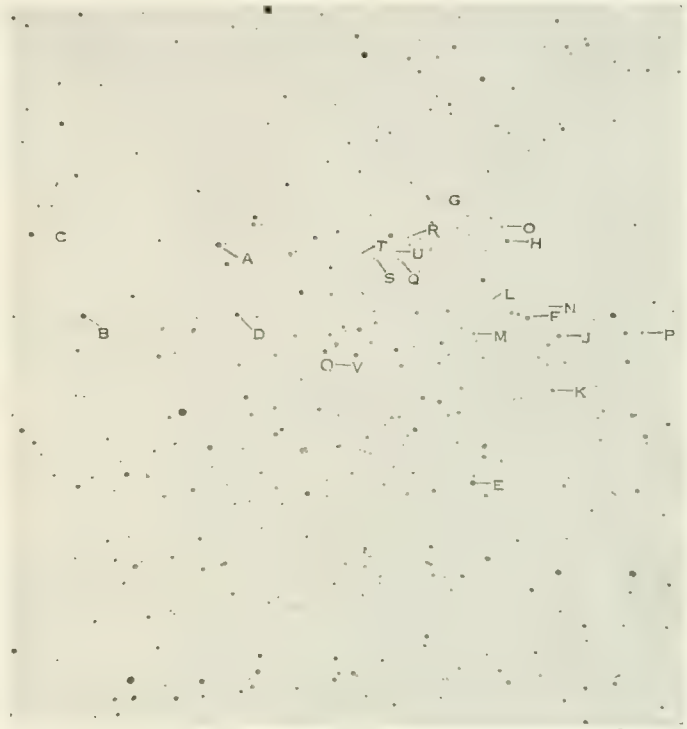
Yerkes negative, 1908, April 5. Scale, 1 mm = 20".5



North

Z SAGITTARII $19^h\ 13^m.8$, $-21^\circ\ 7'$ (1900)

Yerkes negative, 1907, Sept. 11. Scale, 1 mm = 19".7



North

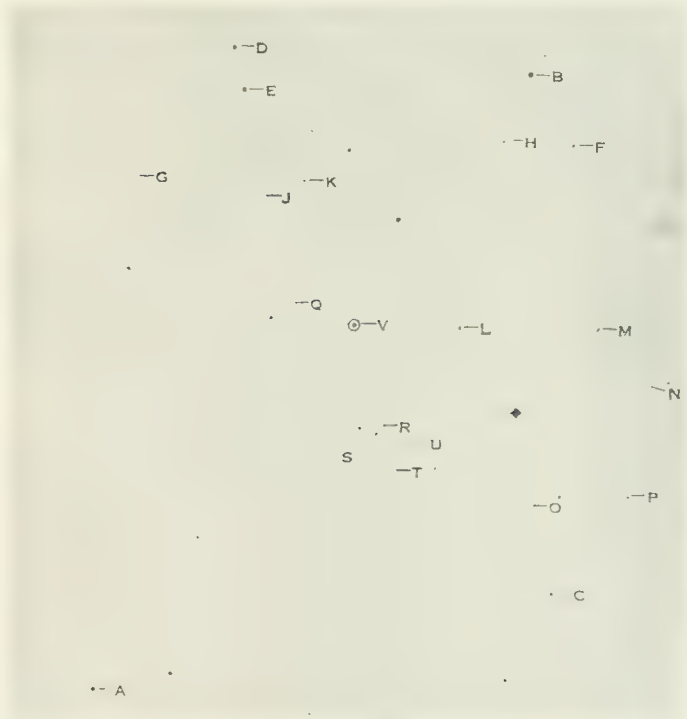
V CAPRICORNI $21^h\ 1^m.8$, $-24^\circ\ 19'$ (1900)

Yerkes negative, 1907, Sept. 11. Scale, 1 mm = 19".6

North

S AQUARII $22^h\ 51^m.8$, $-20^\circ\ 53'$ (1900)

Yerkes negative, 1907, Aug. 12. Scale, 1 mm = 20".1



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V.

CONTRIBUTION TOWARDS A MONOGRAPH

OF THE

LABOULBENIACEÆ.

BY

ROLAND THAXTER

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INTRODUCTORY NOTE.

Since the publication in these Memoirs (Vol. XIII, No. 6, 1908) of the second Part of the writer's "Contribution toward a Monograph of the Laboulbeniales," nine preliminary communications have appeared in the Academy's Proceedings (Vol. 48, Nos. 7 and 10; Vol. 50, No. 2; Vol. 51, No. 1; Vol. 52, Nos. 1 and 10; Vol. 53, No. 9; and Vol. 55, No. 6) which include diagnoses of more than four hundred species and fourteen genera which were previously unrecorded. It has not hitherto been possible to publish figures illustrating these additional species; but it is hoped that this may now be accomplished without undue delay. The new forms have, however, become so numerous that it is impracticable to prepare and publish plates illustrating all of them at once, since, in addition to the number above mentioned, there are still many which have not yet been described.

It has also seemed best to defer any summary or discussion of general matters relating to the Laboulbeniales, except in so far as individual genera are concerned, and to devote a final part to an index of species and hosts, a review of the literature and such other matters as the more recent contributions to our knowledge of these forms may render desirable. Five of the six known genera of unisexual Peyritschiellaceae, three of them monotypic, will therefore be considered in the present connection, an account of the remaining genus, *Trenomyces*, being deferred to a later Part; and for reasons of mechanical convenience, a synopsis of the genera *Hydraeomyces* and *Chitonomyces* is included, although thus taken from their proper sequence.

The accompanying figures are of the usual somewhat unsatisfactory ink-stipple type, and it should be said that, in many cases, no attempt has been made to reproduce different shades of coloration, or suffusion, in individual species. For these characters, therefore, reference should always be made to the descriptions. The latter have been carefully revised, corrected and amended, after renewed examination of the old and often of fresh material.

MONOGRAPH OF THE LABOULBENIACEÆ

PART III.

DIMORPHOMYCETEAE.

This family includes the six genera *Trenomyces, Polyandromyces, Nycteromyces, Dimorphomyces, Dimeromyces* and *Eudimeromyces*, the members of which are all unisexual, the males bearing one or more compound antheridia, in which two or more antheridial cells discharge their sperm-cells into a common cavity, from which they escape through a single opening. As in the corresponding hermaphrodite genera, there is great variation in the complexity of these antheridia, the most complicated being illustrated by the type found in *Polyandromyces:* while in *Eudimeromyces* and the less typical forms of *Dimeromyces*, like *D. Thaxteri*, or *D. aberrans*, the type is much simpler, and approaches that of the simple single antheridium. The functional, or spermogenous, region of these compound forms is intercalary, the cross-septa of one or more terminal cells being absorbed to form a continuous cavity which includes both the sperm-chamber and the efferent canal, the differentiation of which is variably marked in different cases. The family bears the same relation to the hermaphrodite Peyritschielleae that the Herpomyceteae, Amorphomyceteae, and certain other as yet undescribed unisexual types with simple antheridia, bear to the hermaphrodite Laboulbeniaceae. As in these instances, the sex of each individual is predetermined in the ascus, and of the two members of each spore-pair, which are normally discharged simultaneously, one is male and the other female; so that juxtaposition of the sexes is ordinarily assured, when development takes place.

Although, as I have previously pointed out, in hermaphrodite forms where male and female branches are clearly distinguished, as for example in the genus Laboulbenia, the sexual character in either case is by no means fixed; and male organs, especially, frequently develop from the female branch, the differentiation of sex in each individual of the unisexual types seems absolute. No instances have been seen of an anomalous production of antheridia from females, or of perithecia from males, even in such an unusual type as *Dimeromyces adventitiosus*, in which antheridia and perithecia are developed, not only in the normal position from the receptacle, but arise adventitiously from ordinarily sterile portions of the male or female individual, as the case may be.

Among the male individuals of the Dimorphomyceteae, two categories may be distinguished; depending on the relation of the antheridia to the receptacle: for while in *Trenomyces, Streblomyces, Dimeromyces* and *Dimorphomyces* they are always secondary, terminating lateral branches, in *Polyandromyces* and *Eudimeromyces*, they may normally terminate the primary axis. Assuming that my interpretation of the conditions in the type-species of *Eudimeromyces* is correct, this difference in position is not necessarily significant of near relationship; since the last mentioned genus seems far removed from *Polyandromyces*, and evidently related to the simpler types of *Dimeromyces*, like *D. Tomari* or *D. aberrans*, if not actually congeneric with them.

In the female individuals, on the other hand, the perithecia in all the genera are always secondary; terminating lateral branches, and never terminal on the primary axis. Their origin

and relation to the receptacle is essentially the same in all cases; although the production of secondary appendages, or even axes, sometimes results in considerable complication. Further details relating to these matters will be briefly considered under the different genera.

POLYANDROMYCES.

Proc. Am. Acad. Arts & Sci. 55, 215.

Type Species *Polyandromyces coptosomalis.*

The most striking characteristics of this genus are seen in the male. The spores of both sexes are once-septate, and in the male the basal segment divides but once to form the two-celled receptacle; while the distal segment divides in three cells (fig. 1), corresponding to the three primary regions of the antheridium proper: namely; the stalk-cell, which divides no further and is seen as the third cell from the foot in figures 1–6; a terminal cell, figure 1, which becomes pointed, figure 2, dividing in two, figures 4–5, and forming the efferent region; a middle cell which separates a single cell above and below, figures 3–5, the middle of which divides and proliferates to form the very numerous antheridial cells, figures 3–6, the necks of which push up through the upper cell, which is destroyed, and discharge their sperm-cells into the common cavity which is formed by the absorption of the walls separating the two cells of the efferent region, the limits of which are indicated by a corresponding constriction and enlargement, figures 6 and 10. The figures given of the more mature stages are necessarily somewhat diagrammatic; since the antheridial cells are so numerous that it is almost impossible to trace with exactness, in optical section, their origins and relations (figures 6 and 10). The number of sperm-cells discharged is very great, and their formation appears to continue during the entire life of the individual, so that literally millions must be formed during its existence.

In the development of the female individual the upper segment of the spore becomes a short, blunt, two-celled appendage; while the basal cell divides obliquely, immediately below it; separating normally four cells which are successively cut off from the distal end of the basal cell. The uppermost of these forms the base on which the two-celled appendage rests. The next below is sterile, while the third grows out laterally to form the single perithecium. The lowest, or fourth, which is obliquely separated from the basal cell of the receptacle, also grows out somewhat, the outgrowth becoming separated by a septum and closely united to the base of the perithecial stalk. It does not, however, develop further, except in instances where the first perithecium is injured or destroyed, when it may produce a new perithecium. The numbers and relations of the cells as above indicated, seem to be very constant, although variations sometimes occur which are usually the result of injury.

The structure and development of the perithecium appears to present no peculiarities and conforms to that of its near allies. There seems to be but a single ascogenic cell, and the septa separating the stalk-cell, and the basal and lower wall-cells, disappear; so that the lumen of the stalk is continuous with that of the general ascigerous region.

Polyandromyces coptosomalis Thaxter. Plate I, figs. 1–9.

Proc. Am. Ac. Arts & Sci. 55, 216.

Male individual yellow to yellowish brown, the basal cell and efferent chamber and tube paler, or even hyaline; the subbasal cell small and obliquely separated, so that the basal cell is in contact with the squarish stalk-cell of the antheridium on one side, or nearly so. Venter of antheridium, with its supporting cell, deeper brown, subsymmetrical, sometimes inflated, often

abruptly broader than its stalk-cell: the almost dome-shaped efferent chamber separated from the efferent neck by an abrupt constriction and enlargement; the whole straight, or somewhat curved, about 135 μ long. Antheridium 64 × 25 μ; its stalk-cell 16 × 16–21 μ; venter 30 × 26 μ; efferent chamber 125 × 16 μ; neck 22 μ.

Female individual yellowish, becoming more or less deeply tinged with brown; the appendage darker, erect or but slightly divergent; its distal cell slightly longer, somewhat tapering, bluntly rounded. Perithecium erect, nearly symmetrical above the very short curved stalk, the margins slightly convex, the tip and apex clearly distinguished by successive elevations and depressions, which are variably prominent; the apex short, broad, flattened or slightly rounded. Perithecia 240–280 × 50–55 μ. Appendage 30 × 20 μ. Receptacle 105 × 34 μ. Total length to tip of perithecium 300–345 μ.

On legs of *Coptosoma maculatum* Westw. No. 2800 (Type). Madagascar (M. C. Z., Wulsin). On inferior abdomen of *Coptosoma* spp. No. 2960, Suene, Fiji, No. 2960, Wai Ai, Solomon Is., (M. C. Z., Mann).

The material from Fiji and the Solomons is somewhat smaller than that from Madagascar, and grows usually on the margin of the abdomen. The differentiation at the tip is apt to be more pronounced, and the distal cell of the appendage somewhat longer, narrower and more reddish. A rather well defined variety, I have distinguished as

var. MINOR, Plate I, figs. 10–12.

L. c. **55**, 217.

This variety is much smaller, relatively stouter, with a more asymmetrical perithecium, the tip much less clearly differentiated, the apex broader, The perithecia are 135 × 38–150 × 42 μ. Receptacle 40 × 34 μ. Appendage 20 × 12 μ. Total length 160–190 μ. The male 100–105 μ in length, but otherwise entirely similar. Both sexes are distinguishable at a glance from the type, by their small size, but the differences seem insufficient for specific separation. It is found on a small species of *Coptosoma* from Kamerun, No. 3103, and from its habit of growing partly concealed by the projecting segment at the tip of the abdomen, it is detected with difficulty.

NYCTEROMYCES.

Thaxter, l. c. **52**, 653.

Type Species *Nycteromyces streblidinus*.

This genus has been based on a single species, which represents a very distinct type, most nearly related to *Polyandromyces*, from which it is very clearly distinguished by both the characters of the male and female. The antheridia, of which there are several, are more simple in structure, consisting of not more than six cells, possibly only four, and originating as lateral outgrowths, like those of *Dimeromyces*. The receptacle in both sexes is terminated by a peculiarly modified cell, which probably corresponds to the distal segment of the spore, and is seated on a smaller cell, which, though similarly colored, is probably to be regarded as the terminal cell of the receptacle; although, in the original description, they are interpreted as together constituting the appendage. As in *Dimeromyces*, the basal cell of the receptacle, in the male, cuts off successive cells, sometimes as many as five, from which the antheridia arise in a unilateral series; but in the female a single cell, only, is distinguished above the basal cell, and bears the solitary perithecium; unless one regards the lower of the two cells forming the so-called appendage, as also belonging to the receptacle. In neither sex are secondary appendages pro-

duced. The structure of the solitary perithecium conforms to that of other related genera; the walls which separate the basal and stalk-cells being soon absorbed, so that the cavity of the latter is continuous with that of the ascigerous region. The ascogenic cell is single in the type.

NYCTEROMYCES STREBLIDINUS Thaxter. Plate I, figs. 13–15.

L. c. 52, 654.

Male individual hyaline, except the two blackish brown distal cells; the basal relatively long and slender, its base tapering to a point reaching slightly beyond the small black lateral foot: the fertile cells above it, two to five, half as broad as its distal end: antheridia two to five, the relatively short broad stalk-cells and venters superposed in a continuous lateral series, and closely united; the short, stout, blunt, conical efferent chambers and necks diverging slightly upward: the distal appendage-cell pointed, bullet-shaped, blackish brown; the subterminal cell flattened and concolorous. Basal cell of receptacle 40–50 × 10 μ. Antheridia 18 × 12 μ. Terminal cell 18 × 10–14 μ, the subterminal 4 × 15 μ broad. Total length 86–110 μ.

Female individual of rather slender habit, the basal cell hyaline, its upper fourth broader, comparatively long and slender, its base as in the male; subbasal cell small, nearly isodiametric, displaced by the base of the perithecial stalk-cell, which occupies one-half, or more, of the distal margin of the basal cell; the two terminal cells modified as in the male. Perithecium long, the sporogenous portion tinged with dull purplish brown, broader distally, and tapering to the rather broad, flat apex; asymmetrical, the tip bent slightly inward, the successive regions indicated by marginal prominences more prominent on the inner side. Spores 42–45 × 4 μ. Perithecia, including stalk, 210–280 × 36–45 μ; apex and tip 35–40 μ. Basal cell 70–90 × 21 μ; subbasal 10 × 18 μ. Terminal appendage-cell 18 × 14 μ, the subterminal 4 × 16 μ broad. Total length 290–360 μ.

On the superior abdomen and legs of *Strebla vespertilionis* Fabr. No. 2073a, M. C. Z., taken on bats in Venezuela (Carriker).

DIMORPHOMYCES.

Thaxter, l. c. 28, 157.

Type Species *Dimorphomyces denticulatus.*

As I have pointed out in a recent paper on "New Dimorphomyceteae" (Proc. Am. Acad., Vol. 55, p. 212), the additions to this genus and to Dimeromyces, which have accumulated since the publication of the second part of the present Monograph, serve to break down, in some respects, the clearly defined distinctions which formerly seemed to separate these genera. But although, in the light of this added knowledge, their separation now seems somewhat artificial, it is still a convenient one. However closely the two types may approach one another in certain species, the ultimate relation between the subbasal cell, and its primary appendage, to the basal cell of the receptacle in the female, may still be used clearly to separate the one genus from the other. As a matter of convenience it may be desirable again to summarize the differences between the two, since they may be made more clear by reference to the accompanying figures.

In all species of *Dimorphomyces*, the primary subbasal cell, which bears the primary appendage, is always directly related to the basal cell from which it is separated by a common wall, only; and whatever secondary developments may occur, this relation remains unaltered. In *Dimeromyces*, on the other hand, these secondary developments always result in interposing variable numbers of cells between the basal and the primary subbasal cells, so that they do

not remain in contact. The typical conditions characteristic of the two genera may be seen by reference, for example, to figures 27, 54 or 55, in the case of *Dimorphomyces*, and figures 105 or 111, in *Dimeromyces*.

The conditions seen in *Dimorphomyces* result from the secondary activity of the distal end of the basal cell, which pushes up beside the subbasal. From this protrusion of the basal cell, a cell is then cut off which lies beside the subbasal cell, and, from its position, has the appearance of having been derived by separation from this cell, rather than from the basal. The same process is then continued, a further protrusion of the basal cell pushing up beside the cell first separated, and from this second protrusion a second cell is then cut off, which lies beside the first, and like it is in contact with the lumen of the basal cell. As a result of the repetition of this process, more cells are cut off in a similar fashion, their number varying according to the individual or species, and the laterally developed "secondary receptacle," which, in figure 27 for example, consists of seven cells, is thus developed; its cells giving rise to perithecia, or secondary appendages, as the case may be. The seventh cell, which terminates this series, is thus the last or youngest, and, although it is farthest away from the original position of the basal cell, remains, nevertheless, in contact with it. In the figure referred to, the extension of the basal cell has pushed up beyond the seventh cell, although this last protrusion has not been cut off to form an eighth.

Turning to the usual type of development found in species of *Dimeromyces*, one finds that there is no such lateral displacement of the products of division cut off from the distal end of the basal cell; although the process by which they are formed is fundamentally similar. The basal cell, instead of pushing up beside the subbasal before it divides, cuts off at once, immediately below the latter, a first secondary cell, which completely separates the two; and as additional secondary cells continue to be separated distally from the basal cell, the two become more and more remote from one another, the number of cells thus interposed varying in different individuals and species. In figure 411, for example, fourteen such products of the division of the basal cell separate it from the subbasal, which bears the primary appendage represented as diverging at the left. These fourteen cells thus constitute a "secondary" receptacle which, although its axis is coincident with that of the primary receptacle, is entirely similar in character and origin to the laterally divergent secondary receptacle of *Dimorphomyces*. The presence or absence of displacement, through protrusion, in connection with the development of the secondary receptacle, from which the perithecia and secondary appendages are ordinarily developed, is thus the only essential difference between the two genera. Even this distinction tends to disappear in one or two instances among certain somewhat aberrant species. In *Dimeromyces necrotalis*, for example, reference to figure 178 will show that, although the first four cells at the right have been cut off as in other forms of *Dimeromyces*, and completely separate the subbasal cell and its appendage, at the extreme right, from the basal cell; the four secondary cells at the left, which were separated later than those at the right, have arisen through successive protrusion, and are bordered by a marginal extension of the basal cell as in *Dimorphomyces*. Since, however, the subbasal cell, even in this instance, is remote from the basal cell, being separated completely by the four cells intervening at the left, it must be regarded as belonging to *Dimeromyces* rather than to *Dimorphomyces*, although it combines characteristics of both genera. Among other transitional forms *Dimorphomyces Pachytelis*, *D. ramosa* and *D. oblique-septatus* may be mentioned as approaching *Dimeromyces* in the sequence of cell-divisions and cell-arrangement.

In typical species of *Dimorphomyces*, certain variations occur which may be mentioned. While in a majority of cases the female individual develops a single secondary receptacle, or axis, in the manner above described, several are characterized by the production of two such structures, one on either side of the median axis. The second, however, instead of originating from the

basal cell, is derived from the subbasal. The successive steps in its formation and its general structure are, nevertheless, the same, and it is bordered by an extension of the subbasal cell, just as the first is bordered by one of the basal cell. The two species originally described, *D. muticus* and *D. denticulatus*, are both illustrations of this type, and it is very clearly developed in Spegazzini's *D. vulgatissimus*. It also occurs in *D. furcatus*, figures 22–23; *D. Bledii*, figure 35 and *D. Trogophloei* Speg. In all other known instances, however, only one is formed, as in *D. verticalis*, figure 27.

The male individuals of the two genera show no essential differences. It may be mentioned, however, that in *Dimorphomyces* no forms have been seen in which secondary appendages occur; and, as a rule, only one antheridium is normally produced; while forms with numerous antheridia and secondary appendages are not infrequently met with in *Dimeromyces*.

In describing the characters of the male, there has been some confusion in distinguishing the cells of the receptacle proper from the basal cell of the primary appendage; which, as is usually also the case in *Dimeromyces*, is more often undifferentiated by any special form or color. Owing to the fact, however, that the secondary development of the receptacle is set apart in a lateral position in *Dimorphomyces*, there is likely to be less confusion in determining this point, and it has seemed more convenient to assume that the appendage consist of a basal and ordinarily two distal cells, which, as a rule, are much less clearly distinguished than is usually the case in *Dimeromyces*. Twenty species of the genus have thus far been described, of which the six species having two secondary receptacles may be first considered.

In the following citations under species described by myself "l. c." refers in all instances to the Proceedings of this Academy.

Dimorphomyces furcatus Thaxter. Plate I, figs. 22–24.

L. c. 55, 218.

Basal cell of the male individual relatively large, long and uniform, abruptly prominent below the base of the antheridium, obliquely separated from the subbasal; the two deeply suffused with blackish brown, externally. The appendage of three cells, subequal in length; the two distal abruptly more slender. Antheridium straight, erect, subsymmetrical, nearly sessile; efferent chamber distinctly inflated, about as long as the straight neck. Appendage 29 μ. Receptacle, without foot, 32 μ. Antheridium 28.5 × 11.5 μ. Total length to tip of appendage 56 μ.

Female individual furcate, the two secondary receptacles dirty yellow, diverging at different angles and planes; the lower somewhat larger: the eight to sixteen cells bearing perithecia, of which there may be several, and secondary appendages of two kinds; one longer, of four to six cells, having the distal cell distinguished by a slightly constricted broad blackish brown area; the other much shorter, of two cells, blackened. Perithecia relatively large, much longer than the larger secondary appendages; the stalk stout and well developed, but not distinguished from the ascigerous portion; which is somewhat inflated, progressively darker smoky brown to its junction with the well distinguished, abruptly paler, dirty yellowish tip and variably prominent apex, which are subtended by a distinct shallow depression on both sides, the latter slightly distinguished, subsymmetrical, blunt. Primary appendage short, of two cells, finally blackened about the septa. Perithecia 140–180 × 22–27 μ. Longer secondary appendages 45–95 × 8.5 μ. Secondary receptacles 60–95 × 20 μ.

On *Apocellus* sp. Nos. 1581 and 1582; Agua Caliente, Guatemala, (Kellerman).

Since this species was described, several males have been examined. They are distinguished by the deep suffusion on the posterior margin of the receptacle, the abruptly slender two-celled

termination of the appendage, and the straight, nearly symmetrical antheridium. The females vary considerably, but are well distinguished by the various points referred to in the description. The species is most nearly related to *D. vulgatissimus*, which I have not seen, but which appears to differ in the form of its longer appendages, and of its perithecia, as well as in the different relations, in position, of its primary and secondary receptacles to one another. The male of Spegazzini's species is very similar, but lacks the characteristic blackish suffusion of the present form.

Dimorphomyces vulgatissimus Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **23**, 520, fig 63, June, 1912.

This species appears to be closely allied to *D. furcatus*, but is not known to me except through the figures and description of Spegazzini. Although the appendages are represented as dimorphic, they appear to be unlike those of *D. furcatus*, and the secondary receptacles are developed more or less symmetrically on either side, as in *D. Trogophloei* Speg. It is said to be frequent on species of *Apocellus* in the Argentine and at Montevideo, and is a large species; the secondary receptacles reaching a length of 150 μ, the perithecia 200 μ and the secondary appendages 180 μ.

Dimorphomyces Bledii Thaxter. Plate II, figs. 35–37.

L. c. **55**, 217.

Male individual relatively large, the two cells of the receptacle subequal, obliquely separated. The two cells of the primary appendage subequal, distally thick-walled, narrower. Antheridium single, erect; the neck bent inward; the venter inflated, especially on inner side; stalk-cell small and flattened. Antheridium 23 × 9 μ. Appendage 9.5 × 5 μ. Receptacle 13 × 8 μ. Total length to tip of antheridium 42 μ.

Female nearly hyaline or pale yellowish. Receptacle developing fertile axes of six cells, more or less, from both the basal and subbasal cells; the latter smaller and diverging at a slight angle to the former: secondary appendages of two kinds: short, two celled, geniculate, with a dark septum; and very long, seven- to fourteen-celled, flexed, more slender at the base and apex. Perithecia suffused with brown, rather long and slender; the tip blunt, slightly tapering, subtended by two more or less distinct elevations on the inner side. Primary appendage subcylindrical, the two cells subequal, distally rounded. Perithecia 180–135 × 21–22 μ. Primary appendage 25 × 8 μ. Longer secondary appendages 250 × 8 μ, short appendages 20 μ.

On *Bledius emarginatus* Say. Lawrence, Kansas.

The material available of this species is very scanty. In the specimen from which figure 35 was drawn, the distal portion of the perithecium is bent backward, so that the tip is not visible. Figure 37 shows the perithecium from a second individual, in which the general form is more clearly shown, and the slight subterminal elevations at the left are indicated. The species seems most nearly allied to *D. vulgatissimus* Speg.

Dimorphomyces Trogophloei Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 519, fig. 61.

This species is said to occur on the abdomen of *Trogophloeus tenuipunctus* on the island of Santiago, La Plata. The male is not known. The female resembles *D. furcatus*, having two secondary receptacles, and two forms of secondary appendages, as well as perithecia with a subterminal constriction. The latter are, however, differently shaped, with characteristic blunt

tips, and the appendages are not the same; while the two secondary receptacles are symmetrically opposite, and do not diverge at different angles.

Dimorphomyces muticus Thaxter.

L. c. **29**, 104. Monograph, Part I, Mem. Am. Ac. **12**, 267, Plate V, figs. 1–10.

This species has been met with frequently on *Falagria dissecta* in New England, but like *D. denticulatus*, which may be associated with it, it has not been received from other localities.

Dimorphomyces denticulatus Thaxter.

L. c. **28**, 157. Monograph, Part I, 266, Plate V, figs. 1–15.

This species, which is the type of the genus, seems rather rare, and has not yet been recorded outside New England; although it is probably as widely distributed as its common host, *Falagria dissecta*. It grows somewhat concealed at the tip of the abdomen, and is easily recognized by the tooth-like outgrowth which subtends the apex of the perithecium.

Dimorphomyces grenadinus Thaxter. Plate I, figs. 16–18.

L. c. **55**, 221.

Male nearly hyaline, rather slender, the basal cell about half as long as the subbasal, which approximately equals the basal cell of the appendage and the stalk cell of the antheridium in length. Distal portion of the appendage straight, erect, of two nearly equal cells, abruptly slightly narrower, above a thin dark septum, the distal somewhat flask-shaped and pointed. Venter of antheridium straight externally, the neck long, slender, with subconical base, its pointed extremity greatly exceeding the tip of the appendage. Antheridia 35×9 μ. Receptacle 22 μ. Total length to tip of antheridium 75 μ.

Female pale yellowish, becoming faintly brownish, the basal cell of the primary appendage nearly twice as long as broad, similar to the subbasal cell of the receptacle; the distal portion consisting of two cells, the lower short and flattened, the terminal with a neck-like termination. Secondary appendages stout, mostly curved away from the perithecium, somewhat irregular in outline, six- to nine-celled. Perithecium single, next the primary appendage, lateral, the stalk not defined, the distal half or third tapering slightly to the broad termination which is slightly sulcate, angular on the outer and subtended by a variably developed, short, nearly cylindrical projection on the inner side. Perithecia $65–74 \times 17$ μ. Primary appendage $25–35 \times 8$ μ. Secondary appendage, longer, 105×10 μ at base. Total length to tip of perithecia 95–105 μ.

At the tip of the abdomen of a small aleocharid captured by sweeping in the forest at the Grand Etang, Grenada, B. W. I.

The host of this peculiar species has been unfortunately lost, so that its determination has not been possible. The characters are so clearly marked, however, that it is not likely to be confused with any other. The unusually long and slender efferent neck of the male, and the termination of its appendage; as well as the appendiculate apex and peculiar form of the perithecium in the female, serve to distinguish it at once. The female is so twisted, that one usually cannot see the succession of cells in the secondary receptacle; which is usually viewed edgewise, or concealed. Its character is indicated with sufficient clearness, however, in figure 17.

Dimorphomyces Thleoporae Thaxter.

L. c. **35**, 410. Monograph, Part II, 241, Plate XXVIII, figs. 12–13.

Only the scanty original material of this species has been seen. It occurs on *Thleopora corticalis* Götz, from Madeira, and appears to be readily separable from other forms by the blackened, bluntly conical terminations of its short, stout primary appendages in both sexes. In general habit it is not unlike *D. platensis* Speg.; its perithecia are, however, different, and it has but one type of secondary appendage.

Dimorphomyces argentinensis Spegazzini. Plate I, figs. 25–26.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **23**, 187, fig. 14, June, 1912. L. c. **29**, 517, fig. 59, Sept., 1917.
Dimorphomyces Meronerae Thaxter, l. c. **48**, 158, Sept., 1912.

The male individual is distinguished by its clearly differentiated antheridium, of which there may be one or several: the relatively long and slender stalk-cell; abruptly inflated, slightly asymmetrical venter, and rather long, tapering and slender neck and efferent chamber giving it a somewhat characteristic habit. The two-celled primary appendage consists of a large rounded basal, and an abruptly smaller dark terminal cell, with a small apical prominence. The receptacle consists of two subequal cells, the basal subtriangular, the subbasal rounded. Receptacle, including foot, 40 × 23 μ. Appendage 17 μ. Antheridia 32–35 μ, the stalk 9 μ, venter 10 μ, neck 15 μ.

In the female the secondary axis is straight or curved, projecting at right angles to the axis of the primary receptacle. It bears several perithecia, which are relatively slender, nearly straight, slightly asymmetrical and subfusiform, the two lower thirds separated from the upper by a shallow depression, which is associated with a distinct reddish brown suffusion. The secondary appendages are straight, erect, two-celled; the basal cell shorter and rather abruptly broader than the distal. The primary appendage is two-celled, somewhat tinged with reddish brown, especially the distal one, which projects sidewise, and is terminated by a minute rounded apical prominence. Perithecia 65–70 × 12–15 μ. Spores 14 × 1.5 μ. Receptacle, including foot, 18 μ. Secondary receptacle 18–35 μ. Primary appendage 18 × 9 μ; secondary about 30–32 μ.

On *Meronera Sharpi* L. A. No. 1593, vicinity of Buenos Aires.

In revising the proof of my paper on Argentine Laboulbeniales above cited, which was in press at the time Professor Spegazzini's first paper was received, I had no hesitation in retaining my own name *Meronevae*, (a misspelling for *Meronerae*), since the figures he gave appeared to represent a form having quite different perithecial characters, and occurring on a different host, *Myrmedonia*. In his second paper, however, he states that the figures first given represented a variety, occurring in moist situations, in which the perithecia were attenuated. The difference is so great, however, that I have felt some uncertainty whether the two were really the same. In the figures given in his second paper, Spegazzini represents a form having the characteristic suffused distal constriction of the perithecium, which, although more abrupt and circumscribed, is similar to the material examined by myself. The secondary appendages, as represented, are quite unlike those which I have seen, being multicellular above the basal cell, and slender; differing in this respect from those represented in his first paper, which correspond with my own material. It seems, therefore, not impossible that more than one species may occur on this host, and that the name *Meronerae* may have to be retained for a type having slender, constricted perithecia, and two-celled secondary appendages. Spegazzini, in his first paper, represents a

female with eight perithecia, and a male with four antheridia, and speaks of the form as common at various seasons of the year.

Dimorphomyces Myrmedoniae Thaxter.

L. c. **35**, 409. Monograph, Part 2, Plate XXVIII, figs. 14–16.

This species has not been again observed, since its original description, and the preparations have unfortunately deteriorated for some reason. It is more nearly allied to *D. brevirostris*, from which it appears to differ in its larger appendages, and much more divergent secondary receptacle. The type was found on *Myrmedonia flavicornis*, from Guatemala, in the Biologia Collection.

Dimorphomyces platensis Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 517, fig. 63.

This species, of which I have seen no specimens, was found by Spegazzini at La Plata, on *Apocellus parvipennis*. It is said to be nearly allied to *D. vulgatissimus*. The figure represents a form with but one secondary receptacle, having short and long secondary appendages, and a single relatively large perithecium with a pale and rather pointed extremity. The antheridium is represented as stalked and bent outward, at right angles.

Dimorphomyces brevirostris Thaxter. Plate I, figs. 31–34.

L. c. **55**, 219.

Male individual yellowish, becoming brownish, and deeply suffused with blackish in the posterior region of the receptacle; which is two- to three-celled, according as one or two antheridia are developed; the basal cell rather long, extending to the base of the lowest antheridium: the latter suberect, broad, short, subsessile; the efferent apparatus short and stout, truncate. The primary appendage consisting of two cells which, in very young individuals, are surmounted by a slender termination, of one or two cells, which soon disappears. Antheridia 23–26 × 9.5–11 μ. Appendage 13 μ. Receptacle 25–27 × 10 μ. Total length to tip of antheridia 45–50 μ.

Female becoming tinged with brownish yellow, a black patch in the region of the basal cell, which forms a short rather well defined stalk. Primary appendage two-celled through the disappearance of a more slender termination present in very young individuals. Secondary receptacle diverging at an angle of 45°, straight or slightly curved, of six to twelve cells, bearing one to four perithecia and alternating two-celled appendages; which are stout, distally rounded, the cells subequal. Perithecia becoming rather deeply suffused and subfusiform, the tip and apex indicated; when younger and viewed sidewise, the tip somewhat snout-like, with a subtending concavity on the inner side, associated with a brown suffusion. Perithecia 75–106 × 16–20 μ. Primary appendage 23–28 × 10–11.5 μ: secondary 33–42 × 11.5 μ. Secondary receptacle 30–55 × 12–13 μ. Primary basal cell 9 μ.

On the abdomen of *Erchomus* (*Coproporus*) sp., No. 1662, Mandeville, Jamaica, No. 1652, Los Amates, Guatemala: No. 2228, Amazon River.

This species, which is most nearly related to *D. verticalis*, is distinguished by the blackish suffusion about the basal cell in both sexes, and the very short stout antheridium in the male, the efferent neck being exceptionally short and stout. It is similar to *D. Myrmedoniae*. The individuals from the three rather widely separated localities above indicated, show no important variations.

DIMORPHOMYCES VERTICALIS Thaxter. Plate I, figs. 27–30.

L. c. **48,** 159. Spegazzini, Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29,** 519, fig. 62.

Male individual becoming rather dark uniform smoky brown, rather narrow, straight erect, the foot relatively large. Receptacle of two cells, the subbasal somewhat larger than the basal, and extending nearly to its base. Antheridium usually single, erect or but slightly divergent, the neck rather stout. Basal cell of the appendage narrower distally, usually separated from the squarish subbasal cell by a dark septum, the much longer slightly tapering, terminal cell also sometimes thus distinguished. Total length, including foot, 16 μ, about 50–60 × 9 μ. Appendage 14–20 μ. Antheridia about 30–38 μ, including stalk-cell.

Female individual pale, becoming dark smoky brown, or almost black with age. Basal cell of the primary appendage large, somewhat longer than broad; the subbasal cell mostly broader than long, distinguished by dark septa, and becoming deeply suffused; the terminal cell at first hyaline, distally narrower or rounded, thick-walled, becoming more or less disorganized. Secondary receptacle divergent at an angle of about 45° or less, consisting of seven cells, more or less, and bearing one to three or four perithecia, and several secondary appendages, alternating with them and hardly a third as long, stout and bluntly rounded, as a rule, two- to three-celled, becoming often subterminally blackened. Perithecia sometimes elongate, straight or curved, pale, becoming blackish brown, very slightly inflated; the tip bluntly rounded or asymmetrical, and snout-like when viewed sidewise; the hyaline apex subtended on the inner side by a variably distinct darker shade. Perithecia 75–100 × 15–20 μ. Secondary appendages 25–30 μ. Total length to tip of longer perithecia 100–200 μ; to tip of secondary receptacle 75–120 μ.

On the abdomen, less frequently in other situations, on *Atheta* sp., No. 1690 (Type), Palermo, Buenos Aires, and Nos. 1681, 1965 and 1966; also No. 1606, from Isobal, and Nos. 1613, 1624 and 1655 from Los Amates, Guatemala. On *Oxypoda* sp., No. 1501, Lavallol, Argentine. On *Atheta lurida* at St. Catalina, Lavallol (Spegazzini).

This species is subject to considerable variations. Even the male does not always conform to the rather narrow rigid habit of the type form, and may be somewhat stouter. The appendage, which I have regarded as consisting of three cells, while the receptacle is assumed to have but two, varies in length, and in the definition of its dark septa, which may be obsolete. The younger females sometimes resemble *D. brevirostris*, but, apart from other differences, the two are at once distinguished by the character of the male in either case.

Dimorphomyces decipiens nov. comb. Plate VIII, figs. 214–216.

Dimeromyces decipiens Thaxter, l. c. **55,** 263.

Male individual (seen edgewise) rather slender; receptacle of two cells deeply tinged with reddish brown, except the anterior margin and the base of the much larger basal cell. Appendage three-celled, the basal evenly brown, contrasting abruptly with the other two which are hyaline, tapering slightly to the blunt tip, and are separated by a slightly oblique blackish septum. Antheridium somewhat longer than the receptacle and appendage combined, the neck very long and slender, slightly curved. Antheridium 57 × 7.6 μ. Appendage 19 × 5.5 μ at base. Receptacle, without foot, 28 μ. Total length to tip of antheridium 84 μ.

Female individual Y-shaped, the perithecium and the receptacle, above its origin, diverging at somewhat less than a right angle. Basal cell of the receptacle hyaline, or translucent just above the large-foot, then dark red brown or opaque up to and beyond the origin of the single perithecium. Secondary receptacle of about twenty cells, more or less, those of the lower half bearing simple appendages of three or four cells, which are brownish, deeper below; the lowest

heterogeneous, becoming blackened, curved outward towards or past the perithecium; the stalk bent abruptly outwards and causing the perithecium to diverge, not distinguished from the ascigerous region, which is strongly convex externally, and somewhat concave on the inner side, broader distally below the well defined tip; which is distinguished by indentations, deeper on the inner side, its margins somewhat convex; the apex somewhat oblique, distally and externally somewhat rounded and prominent. Perithecia 118–140 × 22–27 μ. Basal (heterogeneous) appendage 50–66 × 5–5.7 μ; the rest about 35 × 6 μ. Total length to tip of axis 140–190 μ.

On the inferior surface at the tip of the abdomen of ? *Eleusis* (*Isomalus*) sp., No. 2359, Kamerun, West Africa.

This species, which was originally placed in *Dimeromyces*, was based on two adult females and one very young individual with a single male. Since these were mounted they have become somewhat cleared, and it is possible to make out their structure, which is obscured by deep suffusions and by the fact that they are viewed edgewise, and to reach a more definite conclusion as to their cell relations. It has seemed desirable for this reason to transfer this form to the present genus; since, in one specimen, it seems possible to determine, figure 215, that the distal cells of the axis are bordered, as in other species of this genus, by an extension of the basal cell. The primary appendage is not visible in the adults, although it is present in the very young specimen; the free part consisting of two small hyaline cells, separated by a somewhat oblique blackened septum. This individual is so turned that its cell relations are also obscured. The heterogeneous appendage appears to arise next the base of the perithecium, from the secondary receptacle. Although the latter is so well developed, and bears a number of appendages, there is no indication that more than one perithecium is formed. In general appearance it suggests an aberrant form of *Rhachomyces*. The single male is also turned edgewise, so that its cell-relations are also underterminable. It is chiefly remarkable for the very long neck of its antheridium, and the somewhat peculiar appendage, which is probably very like that of the female.

Dimorphomyces simplex Thaxter. Plate II, fig. 60.

L. c. **55**, 222.

Male receptacle of normally three cells, the basal pushed outward and upward beside the stalk-cell of the antheridium; the subbasal cell broader than long, the distal smaller. Primary appendage of two to three cells, the distal sometimes brownish. Antheridia arising from the subbasal, sometimes also from the distal, cell of the receptacle; the stalk-cell clearly defined; the neck bent abruptly sidewise at right angles. Receptacle, without foot, 19 μ. Antheridia to curvature 20–23 × 8 μ. Appendage 12 μ. Total length to curvature of neck 38 μ.

Female uniform pale yellowish brown, like the male; the body of the perithecium and distal cell of the appendages darker. Receptacle compact, short and broad. Basal cell short, its lateral prolongation clearly defined and bent upward abruptly beside the outer margin of the secondary appendage, which arises from the outer of the two cells composing the secondary receptacle. Perithecium single and arising from the inner cell of the secondary receptacle, sometimes also from the subbasal cell of the primary receptacle: the stalk long and well distinguished, hyaline, the ascigerous region bent rather abruptly outward, the inner margin abruptly convex near the middle, thence tapering somewhat to the rather pointed apex. Primary appendage of two subequal cells, the slightly narrowed hyaline apex of the distal usually protruding above a brownish disorganized collar. The secondary appendage two-celled above its enclosed basal cell, and similar to the primary. Perithecium 65–80 × 12–15 μ. Receptacle, exclusive of foot (which is relatively very large), 16–20 × 20 μ. Primary appendage 21 × 6 μ. Total length to tip of perithecium 95–105 μ.

On the prothorax and elytra of *Leptoscapha* sp., No. 2388, Mindanao, P. I. (Weber).

The male and female of this species are so firmly united, owing to the unusually large foot, that it has not been possible to examine them separately. The antheridial neck seems well developed, but is turned so abruptly sidewise at right angles that it can only be viewed end-on. The perithecium and its stalk resemble the head and neck of a goose when mature, and are thus very characteristic. Two may occasionally be developed, a second arising, in an unusual position, from the subbasal cell of the receptacle on the inner side. The genus of the host, which was not given in the original description, has been very kindly furnished me by Mr. Arrow.

Dimorphomyces triangularis Thaxter. Plate II, figs. 52–59.

L. c. **55**, p. 224.

Basal cell of the male rather long and narrow, its distal end immediately below the stalk-cell of the antheridium; subbasal cell somewhat shorter, very obliquely separated; the third, distal, cell slightly longer than broad, continuous with the three-celled appendage; the cells of the latter small and short, the distal rounded, the middle squarish, faintly purplish brown, and distinguished above and below by dark septa. Antheridium single, abruptly erect, the outer margin sigmoid, the well developed purplish brown neck curved outward, the individual otherwise hyaline. Antheridia 17 × 5.7 μ. Appendage 6.5 × 3 μ. Receptacle, including foot, 18 μ. Total length to tip of antheridium 32 μ.

Female becoming slightly and unevenly tinged with purplish brown, bent sidewise so that it lies flat on the host. Receptacle small, compact, usually twisted; the basal cell extending below the four or five cells of the horizontal secondary receptacle; the subbasal cell distally broad. The primary appendage of three cells, the basal usually more or less suffused, small, dome-shaped; the terminal becoming brown, and seated on a dark septum. Secondary appendages usually three; erect, consisting of four cells, including the basal cell; the distal greatly but variably elongated, becoming more or less deeply suffused with purplish brown below, the extremities variable and rather abruptly swollen; the subbasal cell distinguished above by a dark septum, slightly broadened. Perithecium triangular, or subtriangular, wholly ascigerous, except the very short narrow stalk which attaches it by its greater angle to the inner cell of the secondary receptacle; hyaline, becoming purplish brown, the short apex only slightly distinguished, and symmetrically rounded. Perithecia 28–30 × 15–17 μ. Primary appendage 10–12 × 7.5 μ, at base; secondary 40–125 μ. Receptacle 22–28 × 11.5 μ.

On the legs of *Celaenopsis* sp., No. 2069 (Type), Wainoni Bay, and No. 2970, Fulakora, Solomon Islands.

This very peculiar species is most nearly related to *D. clavuliferus* and is distinguished by its triangular perithecium and peculiar appendages. The swelling at the tips of the latter vary in abruptness and recall those represented by Spegazzini in *Rickia formicicola*, which may possibly prove to be also a species of *Dimorphomyces*. The swelling is less well marked or even absent from the specimens examined from Fulakora. The form of the perithecium and its relation to the very short stalk recalls the conditions seen in *Dioicomyces malleolaris*. Owing to the irregular twist, which usually occurs during its development, it is very difficult to determine the exact cell relations in mature specimens. They are sufficiently clear, however, in younger forms, and occasionally in adults (figs. 54–55).

Dimorphomyces clavuliferus Thaxter. Plate II, figs. 49–51.

L. c. 55, 223.

Receptacle of the male rather long and narrow, curved, extending to the base of the single antheridium, which seems to be seated on it. The primary appendage consisting of four cells, sometimes subequal, the terminal broadly rounded, the subterminal becoming suffused and distinguished above and below by dark septa. Antheridium subsessile, subsigmoid, asymmetrical, the neck bent outward, or sidewise and outward. Antheridia 16 × 6 μ. Appendage 8–10 × 3.5 μ. Receptacle 15 × 9 μ. Total length to tip of appendage 32 μ.

Female subflabelliform, the basal cell forming a short stalk and extending sidewise at right angles below the four to nine cells of the secondary receptacle. Primary appendage of two or three cells; the distal brown and rounded; the middle, if present, distinguished by dark septa. The first cell of the secondary receptacle producing a single perithecium; the rest secondary appendages, consisting of a terminal, long-clavate cell, which becomes tinged with brown, and two very short basal cells, the upper distinguished above by a dark septum. Perithecium nearly sessile on a very short, abruptly narrow stalk; long ovoid, bent to one side, the tip brownish. Perithecia about 30 × 15 μ. Primary appendage 9–12 × 5.5 μ; secondary 26–28 × 7.5 μ.

On the inferior surface of a species of *Uroscius*. Baguio Mt., Luzon, P. I.

This very minute and peculiar species is most nearly related to *D. triangularis* from which it is distinguished by its short, broadly clavate secondary appendages, and long ovoid perithecium. It was found on a mite contained in the sediment of a miscellaneous lot of beetles very kindly collected for me by Mr. T. V. Reed, at Baguio.

Dimorphomyces obliqueseptatus Thaxter. Plate II, figs. 45–48.

L. c. 55, 225.

Male pale yellowish. Receptacle of three cells, the basal and subbasal subsimilar, or the latter larger; both distally prominent externally, about twice as long as broad. Appendage usually of four cells, the three basal short and rounded; distinguished from one another, and from the long cylindrical distal cell, by well marked black septa. Antheridia one or two, nearly sessile and erect, the regions clearly defined, the neck strongly curved or recurved outward. Receptacle 38–42 μ. Appendage 30 × 5 μ. Antheridia 30 × 8.5 μ. Total length to tip of antheridia 68 μ, of appendage 70 μ.

Female individual pale yellowish, or faintly brownish. Receptacle rather stout and compact, the basal and subbasal cells nearly equal; or the latter larger, reaching nearly to the foot: the three to four cells of the secondary receptacle subtriangular, their axes diverging from the angle between the two, and giving rise to a perithecium and two to three secondary appendages. The former arises either from the first secondary cell, or from the second, figure 46, in which case it is associated with the first secondary appendage springing from the same cell: the second and third cells of the secondary receptacle becoming usually sufficiently displaced to lose contact with the basal cell of the primary receptacle. Primary appendage consisting of a large basal cell bearing the distal part of the appendage terminally, and an often longer branch externally, the base of which occupies its whole outer surface: the free appendage of five cells, the four lower hardly longer than broad; the second and third distinguished by well defined black, transverse septa; the terminal cell variably elongate and tapering: the external branch variably developed, its four subterminal cells short, the second and third, at least, distinguished by dark oblique septa: the secondary appendages similar to this branch, variable, of ten cells or less; the subterminal cells similarly modified. Perithecia erect, the regions hardly indicated, rather short, the

termination blunt and unmodified. Perithecia 55–75 × 13–14 μ. Receptacle 30 × 16 μ. Primary appendage 38–50 × 4.5 μ; its branch and the secondary appendages, longer, 120 μ. Total length to tip of perithecium 105–120 μ.

On the legs of *Pachyteles* sp., Verdant Vale, Arima, Trinidad, B. W. I., No. 2821.

This species, together with *D. Pachytelis* and *D. ramosus*, constitute a somewhat aberrant group to which a fourth species, on a similar host, known to me from Jamaica, W. I., should be added; although the material of this form is insufficient for description. Owing to the compact structure of the secondary receptacle, and the slight displacement of some of its cells, it might not be recognized, at first, as belonging to the type of *Dimorphomyces*. The basal cell remains in contact, however, with the subbasal, as do the first and last cells formed. Like *D. necrotalis* and certain others, the conditions presented serve to break down, to some extent, the distinction supposed clearly to separate the two genera. The material of the present species is scanty, and in part mixed with that of *D. Pachytelis*, to which it is very closely allied. A reexamination of the specimens leads me to feel that, when more abundant material is available, the two may have to be united. Nevertheless *D. Pachytelis* appears to lack the oblique blackened septa, so characteristic of the present form; and the secondary receptacle is made up of but two cells. It is, moreover, a larger species, and the male lacks the well defined differentiation of the antheridial regions, as well as the very characteristically curved, or recurved, efferent neck, figure 48.

Dimorphomyces ramosus Thaxter. Plate II, figs. 38–40.

L. c. **55**, 228.

Male individual similar to that of *D. obliqueseptatus*, more slender, the necks of the two to three antheridia less strongly curved or recurved, and somewhat geniculate. Receptacle, including foot, 55–62 × 17–20 μ. Appendage 38–5.5 μ. Antheridia 30 × 8 μ. Total length to tip of antheridia 85–90 μ, of appendage 100 μ.

Female individual dirty yellowish, with slight brownish tinges. Basal cells rather short, distally pointed, and obliquely separated from three successively smaller cells: namely, the subbasal cell, which is slightly longer, uniformly narrow, and bears the primary appendage distally, and the two much smaller cells of the secondary receptacle, from the inner of which the single perithecium usually arises; while the outer is obliquely associated with the basal cell of the single secondary appendage, to which it gives rise. Basal cell of the primary appendage somewhat shorter than the cell which bears it, producing on either side and subsymmetrically very large, lateral, indeterminate branches, from the angle between which rises the small, nearly uniform, free, determinate primary appendage of about six cells, two of the lower distinguished by dark septa; the lateral branches proliferous, and more or less copiously subdichotomously branched; their primary terminations determinate and persisting, with several successive short cells, several with dark septa; the ultimate proliferating branches strongly flexed, or reflexed. Secondary appendage simple, the terminal portion differentiated like the primary, with dark septa; or variably branched like the branches of the primary appendage. Perithecium large, slightly curved, directed away from the appendages through an abrupt bend at the base of its long undifferentiated stalk-portion; the ascigerous portion slightly shorter, and distally somewhat broader; the tip clearly and abruptly distinguished by subtending elevations, subconical and subsymmetrical. Perithecia 350–425 × 20–22 μ. Receptacle, including the rather large foot, 75–80 × 22–25 μ. Primary appendage 64 × 5 μ; the lateral branches 500 to over 1000 μ.

On the inferior tip of the abdomen of *Pachyteles* sp., Verdant Vale, Arima, Trinidad, B. W. I., No. 2821.

This species, which is represented without great enlargement in figure 38, forms a hairy mass at the tip of the abdomen of the host, owing to the extraordinary development of the proliferous branches of the appendages. It is very closely allied to the two preceding species, from which it differs in its much greater size, differently shaped perithecium and the very characteristic and highly developed system of secondary branches formed by the appendages, the primary terminations of which are left behind by their development. The structure of its receptacle is entirely similar to that of *D. Pachytelis*, which occurred on the same host.

Dimorphomyces Pachytelis Thaxter. Plate II, figs. 41–44.

L. c. 55, 227.

Male individual tinged with brownish yellow. Basal cell long and narrow distally, extending to the base of the antheridium, and prominent below it; the subbasal separated from its upper half by an almost vertical septum; the third cell usually narrower, much shorter, often bearing one or even two accessory antheridia. Primary appendage of usually five cells, tapering distally and curved inward; the four lower cells subequal, but slightly longer than broad; the second and third distinguished by dark septa, sometimes the fourth; the fifth as long as the rest combined. Antheridia one to three, sessile, the venter stout, the efferent neck bent outward, nearly straight, or but slightly curved. Receptacle 65–85 × 18–28 μ, including foot. Appendage, longest, 68 × 6 μ. Antheridia 35–42 × 9.5–11 μ.

Female individuals yellow, with brownish shades. Basal and subbasal cells subequal in length, the latter reaching nearly to the base of the former. Secondary axis usually two-celled, margined by the basal cell; the usually single perithecium arising from the inner, or in conjunction with the single secondary appendage, from the outer; the latter stout rigid, slightly tapering, consisting of about a dozen cells; two to four of its subterminal cells squarish, some with dark transverse septa. Primary appendage consisting of a rather long and narrow basal cell, the rather slender free appendage tapering, of four or five cells, the three or four lower short, the second and third distinguished by dark horizontal septa: the outer face of the basal cell bearing one, usually two, erect branches, which are similar to the secondary appendage. Perithecium straight or curved, becoming yellow, distally broader; the short blunt tip and apex rather clearly distinguished; 100–185 × 18–34 μ. Longer appendages 100–210 μ; primary appendage 100–140 × 6.5 μ; its basal cell 25 × 13 μ. Receptacle 75–125 × 25–40 μ.

On the legs of *Pachyteles* sp., Verdant Vale, Arima, Trinidad, B. W. I., No. 2821.

As has been already mentioned, this form seems to be distinguished from the smaller *D. obliqueseptatus* which accompanied it on the same host, by the straight, or slightly bent neck of the antheridium, and by the invariably transverse blackish septa of the shorter cells in the appendages, as well as in its two-celled secondary receptacle. The relations of the cells and appendages may be clearly seen by reference to figures 42–43, and are of the type of *Dimorphomyces*. The material is not in very good condition, most of the perithecia having been injured.

DIMEROMYCES.

Thaxter, Monograph, Part I, p. 267.

Type Species *Dimeromyces africanus*.

A comparison between this and the genus preceding has already been made under the latter, from which it appears that while in *Dimorphomyces* the basal and subbasal cells remain in contact throughout the development of the individual, they become separated in *Dimeromyces*

by the interposition of a variable number of cells cut off distally from the basal cell. Although the various cell-relations may become disturbed, through accessory branching of the axis, by unusual cell divisions or by secondary displacements, this distinction seems to hold good in all species.

Among the numerous new forms which have been described, and of which seventy-six are enumerated below, many depart so considerably from the original type, that it may be desirable to refer briefly in this connection to some of the more important differences. With reference to the male, the development of the receptacle and appendages shows varying degrees of difference. In the simplest type the receptacle may be regarded as consisting of two cells, the subbasal producing a single antheridium laterally, and surmounted by the usually undifferentiated basal cell of the terminal, primary appendage; the subbasal cell of which is not infrequently distinguished by a blackened basal septum. Such a simple type is represented in figure 138. The distinction between receptacle and appendage is not always clear, and in certain forms, in the male as in the female, there is nothing to indicate where the one ends and the other begins. This is true for example in *D. Thaxteri*, figure 219, but from analogy with the secondary appendages in both sexes, figures 151 and 147, it has seemed best, when a dark septum is present, to regard it as subtending the subbasal cell; although even this characteristic is not always a safe guide, as may be seen in figure 78, the otherwise somewhat aberrant form, *D. subuliferus*, having the simplest male thus far observed, its two-celled receptacle being separated by a dark septum from the two-celled appendage. Except in the even more aberrant *D. adventitiosus*, the number of cells in the primary appendage is seldom more than five or six, more often three, although it may be variably elongated.

With reference to the receptacle, although the simple type consisting of but two cells is more common, it may become much more highly developed through the activity of the distal end of the basal cell, which, as in the female, may divide actively; thus interposing a greater or less number of new cells between itself and the subbasal cell, as for example in figure 112. In a majority of instances, the receptacle produces no secondary appendages, and only one or two antheridia, but in not a few species secondary appendages are formed usually on one side of the axis and associated with antheridia; but sometimes, as in *D. pinnatus*, figured in Part II, Plate XXIX, figure 16, of my Monograph, appendages may be formed in opposite series from both sides of the axis. In general, however, such appendages are few in number and are formed on one side, only; as in figures 152 and 157.

The number of antheridia formed by a given individual may be very constantly only one, or exceptionally two; but in many instances a greater number may be normally formed; as in figures 110, 194 or 197; but the most extraordinary illustration in this connection is seen in *D. adventitiosus*, previously referred to, which not only produces its antheridia in the normal position on the receptacle, but also from any cells of the elongated primary and secondary appendages; so that, as in figure 67, very large numbers may be produced, in this instance thirty-seven.

The structure and development of the antheridium varies in different species, and the exact number of cells and antheridial cells cannot be regarded as generically significant. It is fundamentally the same, however, in all cases, the differences depending on how far development has progressed in a given instance, before it ceases. In *D. Thaxteri*, for example, division ceases at a comparatively early period of development: while in *D. adventitiosus* it progresses beyond this point, so that the resultant antheridium is correspondingly more complicated.

The ordinary development may be illustrated by the accompanying text-figures of *D. adventitiosus*. In this instance a cell of the receptacle, or of one of the appendages, as the case may be, protrudes, the protrusion being cut off as in *a*. The cell thus formed then divides to an upper and a lower, *b*. The upper of these then divides again for the last time, to form a terminal cell

subtended by a smaller flattened cell, *c*. Both these cells later disorganize, except their outer walls, forming a continuous cavity, the terminal one becoming narrower distally, and forming the efferent chamber and neck; while the position of the basal one is occupied by the upward growing necks of the individual antheridial cells. Meantime the lower cell, shown in *b*, separates distally and obliquely a smaller cell, *d*, and its extension, which lies beside the latter, is in turn cut off, thus forming three cells, of which the lower forms the antheridial stalk-cell; while the two above it are either transformed directly to antheridial cells, as in *D. Thaxteri*, figure 219, or undergo further division, *e*, which may result in the production of as many as five, or, in some cases, possibly six antheridial cells, from some or all of which smaller basal cells may or may not be separated, *f*.

In my original description of *D. africanus*, the type of the genus, I stated that the number of antheridial cells was six; but a reëxamination of fresh material has led me to question whether

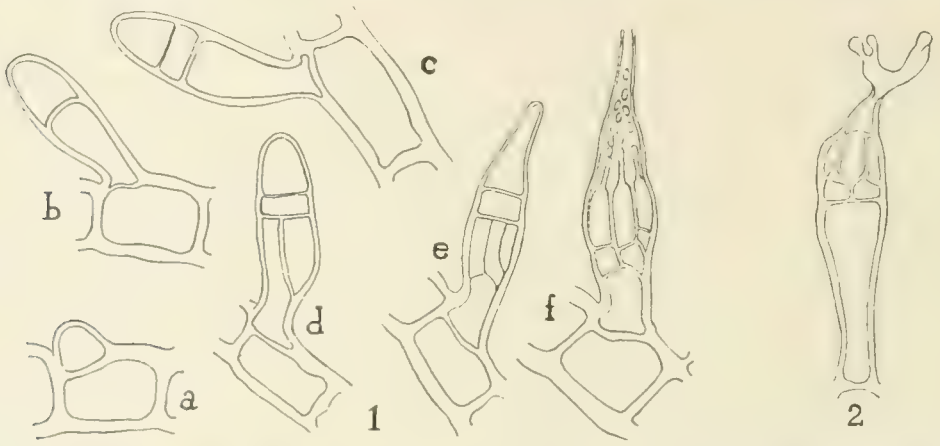

Figure 1. *Dimeromyces adventitiosus*. Development of antheridium. *a*, antheridial mother-cell obliquely separated at left; *b*, further development of the same showing division to an upper and lower cell; *c*, the upper of these cells has divided to a distal and a flattened middle cell, both of which are later destroyed; *d*, the lower cell shown in *b*, has divided, separating a smaller cell above at the right, and in *e*, both these cells have divided, forming the stalk-cell, below, and three antheridial cells above; *f*, the three antheridial cells, which are all that are visible in optical section, have each separated a basal cell and have grown upward distally to form efferent processes, which have traversed and destroyed the flattened cell of fig. *e;* while the distal cell of this figure has become transformed to an efferent chamber and narrower efferent neck, into which all the antheridial cells discharge their sperm-cells. All Leitz water im. oc. 5.

Figure 2. *Dimeromyces africanus* var. showing young perithecium, with basal cells, later destroyed, and terminal trychogyne of the usual type. Zeiss D, oc. 2. All figures without reduction.

there are as many as this, and in some instances there seem to be but four. In *D. adventitiosus*, and some other species, however, there seem surely to be as many as five, while in *D. eximius*, six may even be present. Variations no doubt occur in different antheridia, even of the same species; but it is very difficult to arrive at a satisfactory conclusion as to actual numbers by focussing, even when very high powers are used.

The mature antheridium as a whole consists of a basal "stalk-cell"; a venter, comprising the antheridial cells and their necks and basal cells when the latter are present, and the terminal efferent apparatus, or neck. The Stalk-cell shows considerable variation in its development, and is sometimes very small; so that it may be more or less surrounded by other cells, in which case the antheridium may be sessile, or nearly so, figure 94: while in other instances it may be

variably elongate, bearing the rest of the antheridium free on a well developed stalk, as in figures 219 and 135. The Venter may be relatively large, stout and abruptly distinguished from the stalk, or neck, or from both, as in figure 200, or may be relatively slender, without such clearly marked differentiation. The antheridial cells may or may not cut off small basal cells, as in text-figures 1, *f;* and some, or all, may remain undivided. The Neck also varies greatly from short, stout forms, like that represented in figure 261, to long and slender types, like those shown in figures 83 and 125. A slight enlargement at the base of the neck, forming a chamber into which the sperm-cells are discharged directly from the antheridial necks, is sometimes rather clearly defined, as in *f* of the accompanying text-figure. Often, however, there is little indication of any special enlargement at this point, the whole efferent neck tapering gradually from the distal end of the venter to its terminal pore, through which the sperm-cells finally make their exit. The slender portion of this neck may be straight, or characteristically bent, as in figures 87 or 124, and is sometimes distinguished by special coloration, as in figures 187 and 191.

In a few exceptional cases, the antheridia do not arise directly from cells of the receptacle, but are borne on short unicellular branches arising from them. This seem the normal condition in *D. eximius*, figures 186–187 and may also occur in *D. Thaxteri*, figure 220.

The Foot in the male is variably prominent, and in only one instance is it replaced by a well defined rhizoid. This condition has been figured in the second Part of my Monograph, Plate XXVII, figure 8: but does not seem to occur elsewhere, even in species inhabiting similar hosts, with relatively soft and thin integuments. This is true even in *D. oscinosomalis*, the female of which possesses a penetrating rhizoid.

The variations which may occur in the females of different species parallel, to a certain extent, those above enumerated in the case of the male. The simpler types possess a receptacle consisting of only three or four cells, as in figures 79 and 265; while in others a much greater number may be present, as in figure 111. The Axis of the Receptacle, though usually simple, may, as in the case of the male, develop more or less clearly marked secondary axes. The nature of these axes is not always clear; since, in some cases, they appear to be merely modified secondary appendages, while in others they are of a different nature. In *D. Peltoidis*, for example, figure 68, they are very evidently merely secondary appendages, the basal cells of which are fertile; and this is probably the condition also in *D. crispatus*, figured in my second Monograph. In *D. brachiatus*, on the other hand, figures 72–73, the secondary axis, although sterile, seems to be of the same nature as the primary, bearing similar secondary appendages, although the latter occur on both sides of the axis. The conditions in this very peculiar form recall those which are present in various species of *Rickia* with branching axes, none of which have as yet been figured. In *D. aberrans* the homologies are more obscure, figures 283–284; but, as stated under this species, it seems probable that its characteristic bilateral symmetry results from the modification of a lower secondary appendage. Very few instances of this nature, however, are as yet known, and the primary axis, or receptacle, is typically a simple series of horizontally or obliquely superposed cells: but through displacement in development, or the abnormal or irregular development of individual cells, the fundamental arrangement of the cells may be very much obscured. Such irregularities are well illustrated by figures 79, 80, 85, 185 and 224–227. A striking instance is also seen in *D. subuliferus*, figures 75–77, in which the last two or three cells which are separated from the basal cell, remain small and superposed; while those formed earlier in its development lie side by side, and are disproportionately larger, and separated by nearly vertical septa. These cells give rise to the primary appendage, a heteromorphous secondary appendage, and the perithecium. The latter assumes a median position and might be supposed to be terminal. As a result, the general habit and misplaced cell-relations mimic the conditions seen in the more compact species of *Rickia*, which occur on similar hosts, and for one of which it might well be mistaken at first glance.

The terminal or Primary Appendage is usually well distinguished from the axis of the female, as in figure 79 at left, its basal not infrequently separated from its subbasal cell by a dark septum, as in the instance cited. In many cases, on the other hand, the axes of the receptacle and of the primary appendage merge into one another, without visible distinction, as in figures 212, 217 and 64. It is very variably developed in different cases; sometimes even consisting of but one cell, figure 196; or only two, figure 147; more frequently of several as in figure 237, or 221; but is apt to be conspicuously shorter and less well developed than the secondary appendage, as in figure 201. It is normally simple; but in some cases, as shown in figures 262 and 266, one or more branches may arise from its basal cell.

The Secondary Appendages may be wholly absent, as in figure 236; or copiously developed, as in figures 185 or 232. They are usually simple, although in some instances two or more branches may arise from their basal cells, as in figure 140. They may be relatively short and rudimentary, as in figure 212, or long and of many cells, as in figure 198. They are sometimes of two types, the lower being less differentiated than the upper, as in figure 105; or the reverse may be true, as in figure 271, which illustrates a frequent tendency in the last formed secondary appendage to show a certain individuality which distinguishes it from those above. One of the most striking instances of dimorphism, however, is seen in *D. subuliferus*, figures 76–77, in which the uppermost subulate secondary appendage, which is otherwise anomalous in developing later than the rest, is entirely unlike them, both in form and color. *D. Dhanyae*, figure 85, is another remarkable case of dimorphism, in which the lower appendage is quite anomalous in form.

The Perithecia are normally single in a majority of the species, as in figure 196; or in a few instances there may be as many as five or six, as in figure 181. Apart from variable elongation of the stalk and a certain amount of differentiation at the tip, they present few peculiarities, and are similar to those of *Dimorphomyces*. In a few cases appendages, or outgrowths, are developed, which are distinctive, as in *Dimeromyces mucronatus* and *D. falcatus* of Paoli, in *D. Hyperacanthae*, and *D. appendiculatus*, which has a well developed "trigger-organ," such as I have described in *Ilytheomyces*, and in other instances.

The Foot in all known species, except *D. oscinosomalis* and *D. coarctatus*, is of the usual type, the two species last mentioned being the only ones which penetrate the host by means of a rhizoid.

In the following enumeration, which includes all described forms, I have found so unsatisfactory any attempt to arrange the species serially, according to their apparent relationships, that I have chosen to distribute them according to the host-families; since, in general, though not in all cases, this arrangement serves to bring together related groups. A half dozen additional species known to me, are here omitted, owing to the fact that the material is too scanty, or not in sufficiently good condition for description: the hosts of which add three more families to the coleopterous hosts. In all, the species are seventy-seven in number, fifty-two occurring on Coleoptera, six on Diptera, thirteen on Orthoptera and six on Acarina.

Of the species found on Coleoptera, twenty inhabit Tenebrionidae, eleven Chrysomelidae, eight Carabidae, four Staphylinidae, two Cryptophagidae and one each Corylophidae, Phalacridae, Cucujidae, Cleridae, Anthicidae and Endomychidae.

The dipterous hosts are mostly undetermined, but at least two belong to the Oscinidae.

Among the Orthoptera one form occurs on Gryllidae, while twelve others are found on Forficulidae; and in the Acarina six species are found in several families.

It is of interest to note, in this connection, that the largest number of species are parasitic on Tenebrionidae, a family on which as far as I am aware, no other genus has been found, and also that only 5% occur on Staphylinidae, while in Dimorphomyces 80% are parasitic on members of this family.

SPECIES PARASITIC ON COLEOPTERA.

1. ON CARABIDAE.

Dimeromyces nanomasculus Thaxter.

L. c. **35**, 411, 1900. Monograph, Part 2, 245, Plate XXIX, figs. 10–13.

This species, occurring on *Ardistomis viridis* Say in Florida, and on *Ardistomis* sp. from Central America, has not been seen since its original description.

Dimeromyces pinnatus Thaxter.

L. c. **25**, 410, 1900. Monograph, Part 2, 246; Plate XXIX, figs. 16–18.

It is very desirable that this remarkable form should be reexamined, in the light of fresh material. It has not, however, been again seen, since its original description, and it still remains uncertain whether the figures above cited represent a single species, or whether the form on the legs, represented in figure 17, may not need to be separated as a distinct species. It is quite possible, however, that the different conformation of its perithecium and the variation of its appendages may have resulted from its different position of growth. What I have regarded as the Type is represented by figure 16. The species occurs on a carabid, at least closely allied to *Ardistomis*, probably from Central America.

Dimeromyces Petchi Thaxter. Plate VII, figs. 188–191.

L. c. **51**, 7.

Male individual hyaline, subtriangular, or sometimes more elongate, of seven to ten cells: the basal more often short and triangular, the rest flattened and obliquely superposed: basal cell of primary appendage short, subtriangular, or externally prominent; subbasal cell small, slightly suffused, abruptly distinguished by a blackened septum; the rest of the appendage of two or three cells, often slightly tapering, rather short, becoming distally disorganized. Antheridia three to often six, sometimes eight, more or less displaced by crowding: short, stout, the stalk-cell well defined, forming an angle between the two antheridial cells, from which no basal cells are separated; the venter rather short and stout, not abruptly distinguished; base of the neck contrasting black, its distal portion quite hyaline, bent abruptly above its base at an angle of 45°–90°. Receptacle, including small foot, 45–80 × 15–20 μ. Primary appendage 45 × 5.5 μ near base. Antheridia about 28 × 9 μ.

Female individual hyaline, the receptacle of three or four cells; the basal longer, the rest somewhat obliquely superposed and slightly broader than long: the primary appendage similar to that of the male, of four or five cells. A single secondary appendage arising from the subbasal cell, similar to the primary, but usually somewhat longer, and similarly distinguished by a black septum. Perithecium usually arising from the third cell of the receptacle; erect, or usually bent abruptly sidewise at the base, almost sessile, asymmetrical, translucent, pale smoky brown, distally somewhat prominent externally below the rather abruptly distinguished tip, the base of which is more deeply suffused with blackish brown, and forms a more or less distinct blackish band, above which it is hyaline, except for a deep blackish suffusion just below the hyaline apex; which is slightly broadened, irregularly rounded and slightly bent. Spores 30 × 4 μ. Perithecia 75 × 20–24 μ. Receptacle 55–65 × 25 μ. Appendages about 40–45 × 7–8 μ. Total length to tip of perithecium 120–135 μ.

On the right inferior posterior surface of the prothorax of species of *Perigona* ?, No. 2116a (Type), Kuching, Borneo; No. 2093b, Peradenyia, Ceylon, No. 2081c, Samarang, Java; Nos. 2398, 2400 and 3029, Philippines, Manila and Los Baños.

This species was first found on hosts kindly sent me by Mr. T. Petch from Perdenyia, Ceylon, to whom the form is dedicated. It is especially interesting for the reason that the only other nearly allied form, *D. caribbeus*, which occurs in the same position on a similar host in the West Indies, is distinguished from it almost wholly by the characters of the male; which, in the present species, is quite remarkable in appearance, from the characters of its antheridia shown in figures 190–191, and which appear to be invariable in all the material examined from widely separated localities. The specimens of both sexes from Java differ in their more elongate habit, and may be worthy of varietal rank; but more abundant material is needed to determine this point. The differences which separated the two species are referred to under *D. caribbeus*. Short stout individuals sometimes occur, in both forms, on the legs of the host adjacent to the normal position.

Dimeromyces caribbeus Thaxter. Plate VII, figs. 192–195.

L. c. 55, 260.

Male individual hyaline, erect, rather slender. Receptacle consisting of from four to seven cells obliquely superposed, straight or slightly curved backward, of nearly uniform diameter, the basal cell much longer, narrower below. Basal cell of the primary appendage hardly longer than broad; the subbasal abruptly slightly broader, rounded, faintly suffused, separated by a black constricted septum from the two remaining cells; the distal longer, its end rounded, and becoming disorganized. Antheridia two to six, hyaline throughout, slender, the stalk relatively long, the neck rather strongly curved outward distally. Antheridia 28 × 5.5 μ. Receptacle 38–45 × 8 μ. Appendage 26–32 μ.

Female individual faintly tinged with yellowish or brownish, the appendages and perithecium darker. Receptacle of four superposed cells, the basal larger; the primary appendage of usually four cells; the distal longer and becoming disorganized at the tip; the subbasal rounded, brownish, with blackened constricted basal septum. The subbasal cell of the receptacle giving rise to the single brownish secondary appendage, which is usually five-celled, the terminal cell, as a rule, swollen and gelatinized; the subbasal with a blackish basal septum; the whole bent nearly parallel to the primary appendage, and sometimes reaching its tip. Perithecium single, arising from the third cell, and diverging sidewise at an angle of about 45°, sessile, broader distally; the tip delimited by a narrow, clearly defined blackish collar and constriction; the apex rounded, or the lips more or less distinct, clearly defined, and subtended by blackish suffusions. Perithecium 65–76 × 20–22 μ. Receptacle 48 × 18 μ. Primary appendage 25–30 μ; secondary up to 55 μ. Total length 100–120 μ.

On the legs and inferior anterior prothorax of *Perigona* sp., Grand Etang, Grenada, B. W. I.

Specimens growing on the legs vary from the type, as shown in fig. 193, the appendages and perithecium being erect and parallel, and the general habit stouter. The species is very remarkable for the close resemblance of the female to that of *D. Petchi*, which differs in its larger receptacle, and more divergent perithecium, the tip of which lacks the basal constriction and clearly defined black collar of the present species. The males, however, are quite unlike, as may be seen by reference to figures 190 and 194. Neither form seems nearly allied to any other species.

Dimeromyces Lavagnei Picard.

Bull. Sci. France et Belgique. **50**, 440, 1917. Maire 3-me Contr. a l'Étude des Laboulbéniales de l'Afrique du Nord. Publication de l'Université d'Alger, 1920, p. 8, fig. 1.

This form, which is not known to me except through the descriptions and figure above cited, appears to be rather a species of *Dimorphomyces* than of the present genus, since the three-celled "raquette-shaped" primary appendage is said to arise from the subbasal cell. If the peculiarly differentiated appendage thus designated is really primary, the form certainly cannot be included in *Dimeromyces*. It has been found in France by Picard on the elytra of the carabid, *Blechrus minutulus*, and by Maire in Algeria on *B. laevipennis* Lucas. In neither case were male individuals observed, and Picard states that the assignment of the species to *Dimeromyces* is merely provisional.

Dimeromyces eximius Thaxter. Plate VII, figs. 185–187.

L. c. **55**, 259.

Male individual relatively large: receptacle nearly opaque, except the basal and the lower portion of the subbasal cell: consisting of about five superposed cells; the two or three above the basal, much flattened and oblique (45°), terminated by an undifferentiated appendage of two cells, the lower much larger; the upper shorter and narrower, slightly translucent, especially its broad flattened distal margin: the successive cells above the basal cell of the receptacle producing an anterior series of unicellular branches or protrusions, from each of which may arise one or more antheridia, or appendages, or both combined: the appendages stiff, simple, faintly brownish, rather closely septate; the septa darker and slightly constricted, slightly divergent: the antheridia sessile, rather short and stout, the three regions very clearly distinguished; the venter but faintly suffused, its margins nearly straight, or convex on the inner side; the efferent base of the neck abruptly distinguished, deeply suffused on one side at least, relatively very broad, slightly longer than the short-clavate, distal portion which is bent slightly inward: the insertion of the individual antheridia, as well as of the appendages, rather conspicuously blackened. Receptacle, including large foot, 58 × 15 μ. Primary appendage 22 × 12 μ; secondary 130 μ or more × 8 μ. Antheridia 38–44 × 13 μ. Total length to tip of appendage 82 μ.

Female individual similar in general structure and appearance to the male, the secondary appendages more numerous and elongate, curved upward and inward, distinctly brownish; the septa darker, with a slight constriction. Primary appendage quite opaque above the basal cell. Perithecia one or two lying at the left, as do the antheridia in the male, while the secondary appendages, except the two or three lowest, lie at the right: the perithecial stalk very short, nearly hyaline, abruptly bent; the rest deeply suffused with reddish brown, large, broader distally, almost opaque: the tip-region translucent, more or less clearly defined above and below by a fine dark line: the apex larger and longer than the tip-region, asymmetrical, tapering rather abruptly, the inner two thirds much darker, especially the prominent overarching upper lips; the outer third concolorous with the tip-region. Perithecia 135–160 × 32–38 μ. Secondary appendages, longest, 275 × 9 μ. Axis, including foot and primary appendage, 100–110 × 23–25 μ.

On the anterior legs of *Pachyteles* sp., Verdant Vale, Arima, Trinidad, No. 2821.

This form is one of the most striking and peculiar members of the genus. Apart from the general structure and deep suffusions of both sexes, the male is distinguished by the very unusual shape and coloration of its antheridia, which appear to have at least six antheridial cells, and the presence of secondary appendages, which may arise with one or more antheridia on short branches, or protrusions, from the receptacle. The receptacle of the female becomes quite opaque above

the basal cell, but in somewhat younger individuals it may be seen to consist of about eight flattened, obliquely superposed cells; the fourth producing the first perithecium, the third apparently producing a second, figure 185, while the rest, above the basal, bear secondary appendages, which seem also to be associated with the perithecia somewhat as they are with the antheridia, figure 187. The appendages approach the type seen in *D. Aulacophorae* and its allies, consisting of a basal cell, or protrusion, which may bear two, possibly more, stiff, simple, slender branches of rather uniform diameter; the numerous cells of which, especially in those higher up, are separated by dark septa and slight constrictions. The primary appendage in the female is not distinguished from the receptacle, being involved in the general opacity of the latter, and its limits are thus not determinable. In young individuals there may perhaps exist some definite termination, which is soon disorganized or destroyed. Although so unusual in its characters, I should be inclined to place this form nearer *D. Aulacophorae* and its allies than to other known types.

Dimeromyces africanus Thaxter.

Monograph, Part I, p. 268. Plate IV, figs. 12–18.

This species, which is the type of the genus, occurs on *Pachyteles* in West Africa; and, since its original description, has been again found on hosts received from Kamerun, which were kindly sent me by Mr. Schwab. It is not confined to any special position on the insect, but in one instance a dense group was found at the tip of the abdomen, the individuals of which are somewhat specialized and vary from the type in being darker and more strict. The number of cells in the receptacle may vary from seven to fifteen, and the depth of the suffusion differs greatly, especially in the appendages; the deep blackish brown coloration of the subbasal cell sometimes involving several of the cells above. The species is most nearly allied in *D. maculatus*.

Dimeromyces maculatus Thaxter. Plate IX, figs. 232–235.

L. c. 55, 262.

Male individual pale yellowish, becoming tinged with brownish. Receptacle rather stout, asymmetrically clavate, consisting of from five to ten cells, greatly flattened and very oblique; the basal larger and usually abruptly bent. Primary appendage erect, rather elongate, tapering; the basal cell larger, obscurely finely granular or punctate; the second, and to a less degree the third, suffused with dark red-brown, especially at the septa, which show slight constrictions; the rest of the appendage tapering, pale, its lower cells sometimes darker and slightly inflated, tinged with purplish. Antheridia one or two to seven, sometimes associated with one, or less often two, secondary appendages similar to the primary, or with the cell unmodified; but longer and stouter, with longer basal cells: the antheridia tinged with purplish, the regions clearly distinguished, the stalk-cell short and free, or partly so; the neck straight or slightly bent; the base and apex nearly hyaline; the rest purplish brown, as is the clearly distinguished efferent region at its base. Receptacle 50–65 × 20–25 μ. Appendage, primary, 115–150 μ: secondary, longer, 190 μ. Antheridia, average, 48 × 9 μ.

Female individual extremely variable in its size and the development of its appendages. Receptacle faintly yellowish, becoming tinged with brown, the cell-walls forming the posterior margin brown to deep blackish brown; tending to become very short and stout, sometimes nearly as broad as long, with the anterior margin subhorizontal; consisting of eight to thirteen cells, very greatly flattened and very obliquely superposed, or the transverse diameters nearly vertical. Primary appendage similar to that of the male, usually more conspicuously granular-punctate; secondary appendages two or three to six or seven, stouter; a basal and distal portion more or

less clearly distinguished; the former paler, stouter, of one to rarely six cells, punctate with scattered brown spots, which are slight thickenings of the wall; the distal portion resembling the primary appendage in a general way, more slender, one or more of its cells from below up abruptly darker, the depth and extent of the suffusion variable; the lowest cell sometimes almost opaque with straight, or slightly concave, margins. Perithecia variably elongated, one to several irregularly associated with the appendages, the stalk-portion often much longer than the ascigerous part, and variably distinguished from it; the whole straight and symmetrical, or less often variably curved; the tip deeply and rather abruptly suffused with clear reddish brown, the short, broad, flat or broadly rounded apex hyaline, or partly involved by the suffusion of the tip. Perithecia 100–360 × 20–30 μ. Receptacle 80–110 × 25–45 μ. Primary appendage 125–200 μ; secondary 150–550 μ.

On the elytra and inferior thorax of *Sphaerotylus Wyliei* Murr., No. 3089, Kamerun, West Africa.

This very striking species is most nearly related to *D. gonocnemalis* and *D. africanus*, especially to the former, which, however, differs in various important points, notably in the male, the appendage and antheridia of which are quite different. Although the appendages of the female in *D. gonocnemalis* show faint indications of maculation, their character is very dissimilar, and the receptacle is also quite different. Figure 232 is drawn from a group of unusually well developed individuals growing at the base of the anterior legs. Individuals on the elytra are mostly much smaller, with but a single basal maculate cell in the secondary appendages, the distal portion of which is usually more abruptly and deeply suffused.

Dimeromyces Dhanyae Thaxter. Plate IV, figs. 84–87.

L. c. **55**, 239.

Male individual dull olivaceous brown. Receptacle consisting of three very unequal and oblique, or nearly vertical, cells; the basal extending upward anteriorly almost as high as its extremity, beside the narrow subbasal cell, from which a smaller cell is separated distally; in contact also with the base of the distal cell, which is somewhat shorter and bears distally the three-celled appendage, of which the basal and much shorter subbasal cells are paler and together about as long as the abruptly much more deeply suffused terminal cell, which is slightly irregular and tapering, ending in a bluntly pointed knob-like extremity. Antheridium turned against the appendage, the basally swollen or geniculate, somewhat irregular, dark brownish, slightly tapering and irregular neck bent abruptly away from its tip, the venter relatively short, the stalk-cell small and enclosed. Length to tip of appendage, including foot, 65–70 μ. Terminal cell of appendage 11–13 × 5.7 μ. Antheridium about 44 × 13 μ.

Female individual compact, partly suffused with blackish brown. Receptacle subtriangular consisting of usually four cells, very oblique or nearly vertical, unequal and somewhat irregular, the very large basal cell extending upward along the anterior face, prominent distally above an external, deep blackish brown suffusion near the middle of its outer margin; the subbasal cell small and narrow, bearing a two-celled, deeply suffused, short, broad, rounded, aberrant secondary appendage, the narrowed extremity of which is bent abruptly inward, ending in a flat rounded hyaline termination. Primary appendage very much as in the male, the basal cell relatively shorter and broader. Perithecium arising partly laterally from the subterminal, apparently sometimes also from the terminal cell; erect, the stalk opaque, except above its base, rather abruptly and clearly distinguished from the ascigerous portion, which is strongly inflated, somewhat more convex on the inner side, opaque, or deeply suffused below, above transversely mottled and translucent; the distal half subconical; the termination somewhat oblique; subtended by deeper

suffusions. Stalk of perithecium 48–58 × 20–22 μ; ascigerous portion 75 × 38–42 μ. Receptacle 48 × 38 μ. Terminal cell of primary appendage 15 × 7.5 μ: aberrant appendage 28 × 19 μ. Total length to tip of perithecium 190 μ.

On the inferior tip of abdomen of *Dhanya* sp., Mindanao, P. I., No. 2389.

I am indebted to Professor Oakes Ames for the host of this species, which was collected in the Philippines by Mr. Webber. It is very unusual and striking in appearance, and could not be mistaken for any of the other species thus far described. The neck of the antheridium remotely resembles that of *D. Australasiae*, but the two forms are not related. The aberrant appendage is unlike that of any species known, and the general appearance of the female individuals, of which but two fully developed specimens have been examined, recalls that of *Cucujomyces Diplocoeli* and *C. curtipes*, the perithecium having a similar series of transverse mottled lines. The structure, which, in two specimens, is developed from the terminal cell of the receptacle, and was thought to be a second appendage, seems rather to be an undeveloped perithecium, figure 84.

2. ON STAPHYLINIDAE.

Dimeromyces gracilis Thaxter. Plate VIII, fig. 211.

L. c. **55**, 267.

Male individual very minute, the receptacle apparently consisting of but two cells, the two-celled appendage undifferentiated, its basal cell small and rounded; the distal two or three times as long, distally rounded, the wall undergoing gelatinous disorganization. The single minute antheridium arising from the subbasal cell, apparently sessile, with a short neck. Total length to tip of appendage (including foot) 34 μ.

Female individual almost hyaline. The receptacle consisting of four or five cells terminated by an undifferentiated two-celled appendage, like that of the male, and distally similarly disorganized. The third cell of the receptacle producing the single perithecium, which is long and slender, the stalk-portion not distinguished, of nearly uniform diameter, or slightly narrower at the base, the relatively long tapering tip-region not well distinguished, the apex small and rounded. Perithecia 150–190 × 20 μ. Receptacle, including foot, 48–56 × 12 μ. Appendage 22 × 18 μ.

On the leg and tip of abdomen of a myrmecophilous aleocharid, No. 2612, Kamerun, West Africa.

One immature and two mature female individuals of this simple and curious form have been examined, neither of which, though well developed, bear any secondary appendage. A small cell is, however, separated distally from the subbasal cell, just below the insertion of the single perithecium. The only male examined is still adherent to the foot of the female, and is so placed that the minute antheridium lies above the receptacle and is hardly distinguishable, so that its structure is barely indicated. The host was taken by Mr. Schwab among various other Staphylinidae which were following in the rear of a procession of soldier ants.

Dimeromyces Roreri Thaxter. Plate VII, figs. 174–177.

L. c. **55**, 266.

Male individual hyaline, becoming very faintly tinged with yellowish brown. Receptacle of two, rarely three, cells, erect; the appendage of three cells, the middle roundish, distinguished by thin dark septa, the basal abruptly somewhat broader than the distal cell of the receptacle, and faintly suffused. Antheridia one or two, slightly asymmetrical, the inner margin more convex; the stalk well developed, as long as the venter, the neck distally rather slender. Receptacle,

without foot, 12–13 × 8 μ, foot small. Appendage 12 μ. Antheridia 38 × 8.5 μ. Total length 48–54 μ.

Female individual nearly hyaline, with faint yellowish brown suffusions. Receptacle of six or seven flattened, oblique, or somewhat irregular-cells. Primary appendage similar to that of the male. Secondary appendage from the fourth cell, of five or six cells, the second and third somewhat longer than broad, distinguished by thin dark septa. Perithecia one or two, from the fifth, or third and fifth cells, erect and bent slightly sidewise; the short stalk not distinguished, the ascigerous part somewhat broadened distally, the curvature of the margins even, subsymmetrical; the tip slightly inflated, abruptly distinguished by a slight constriction associated with a deep contrasting blackish brown suffusion, which forms a collar, above which it is rather abruptly somewhat narrower and bent inward; the apex rather clearly distinguished, narrower, and of nearly uniform width, with rounded termination. Perithecium 80–100 × 17–19 μ. Receptacle 20–25 × 12–13 μ. Primary appendage 16–20 μ; secondary 42 × 5 μ. Total length to tip of perithecium 105–125 μ.

On the inferior surface at the tip of the abdomen of *Gyrophaena* sp., Port of Spain, Trinidad, No. 2306.

The host bearing this very pretty and distinct species was sent to me by Mr. J. B. Rorer to whom it is dedicated. It bears a certain resemblance to *D. caribbeus*, especially owing to the suffused collar which subtends the tip, and it is perhaps more nearly allied to this species than to any other. Owing to the basal curvature of the perithecium, individuals lie more often with the receptacle seen edgewise, so that it is difficult to represent the normal sequence of the cells.

Dimeromyces Gyrophaenæ Thaxter. Plate VII, figs. 180–182.

L. c. **55**, 268.

Male individual hyaline, faintly tinged with yellowish. Receptacle consisting of four or five slightly flattened and oblique cells, the basal as long as the rest combined. Appendage short, stout, of two cells; the distal slightly longer, broadly rounded, thick-walled. Antheridia three or four, diverging at about 45°; the stalk but slightly shorter than the neck and venter; the former short, stout, conical. Receptacle 34 × 12–13 μ. Appendage 17 × 8 μ. Antheridia 30 × 8.5 μ. Total length to tips of antheridia 64 μ.

Female individual pale yellowish. Receptacle, above the basal cell, bent sometimes at right angles to the axis of the latter: consisting of usually eighteen to twenty cells, those above the basal very greatly flattened, especially the lower: giving rise alternately to perithecia and appendages, which diverge slightly, left and right respectively, projecting upward from the nearly horizontal receptacle. Primary appendage like that of the male: secondary appendages usually of four cells, the three lower subequal, hardly longer than broad, the distal one somewhat broader, rounded and thick-walled. Perithecia subclavate, curved, tapering to the slightly bent, short tip, and rather small asymmetrical apex. Perithecia 75–80 × 21 μ. Receptacle above basal cell, 55–70 × 20–25 μ. Primary appendage 17–19 μ; secondary 46 μ.

On the elytra of *Gyrophaena* sp., No. 2610, Kamerun, West Africa.

The perithecia of this species are apt to be so abruptly bent at the tips that it is difficult to determine their outlines. It is distinguished by its short stout form, abrupt curvature and numerous alternating short blunt appendages and perithecia. It is perhaps as closely allied to *D. Copropori* as to any other species, but is very abundantly distinct, and quite unrelated to *D. Roreri* which occurs on another species of the same genus.

DIMEROMYCES COPROPORI Thaxter. Plate VIII, figs. 212–213.

L. c. 55, 266.

Male individual becoming more or less tinged with brown, rather short and stout. Receptacle of three cells obliquely superposed, the basal pale and longer; bent outward rather abruptly above cell 2, cell 3 and the basal cell of the short, blunt, two-celled appendage more deeply suffused, even opaque. Antheridia normally two, arising from the second and third cells, rather short and stout; the upper but slightly higher than the lower, their axes parallel to the distal part of the receptacle and appendage; the stalk-cell short, but well defined, and free externally; the neck short, tapering rapidly from its broad base. Receptacle, without foot, 20 × 12 μ. Appendage 13 μ. Antheridia 30 × 9 μ. Total length to tips of antheridia 58–62 μ.

Female individual large and stout, more or less suffused with yellowish brown. Receptacle erect, slightly curved backward distally; consisting of about sixteen to twenty-five flattened cells, oblique only above the point of curvature; all except the lowest producing short, rounded, two-celled, abortive appendages, or unicellular protrusions, or sometimes both; and from four to seven perithecia, the two usually alternating. Primary appendage not distinguished from the receptacle, consisting of two or three cells ending bluntly. Perithecia nearly sessile, stout, of more or less uniform diameter; the tip distinguished by its darker color, below the broad, flat, nearly hyaline apex, 100–125 × 20–25 μ. Receptacle, including foot and primary appendage, 125–180 × 25–28 μ. Secondary appendages 18 × 10 μ. Total length to tips of perithecia 225–260 μ.

On the legs of an undescribed species of *Coproporus*, No. 2620, Kamerun, West Africa.

This very distinct form is not clearly related to any of the described species, and is the only one which occurs on this host-genus. It is perhaps more nearly comparable to *D. Thaxteri*, in which the receptacle and primary appendage are also continuous and undistinguished; a condition also found in *D. gracilis*, and, to a less marked degree, in various other forms. The secondary appendages are usually associated with conspicuous protrusions from their basal cells, which may replace them above, and may protrude from either side in different cases. These appendages themselves vary somewhat, and are sometimes less stout and taper slightly. The material is sufficient and in good condition.

3. ON CORYLOPHIDAE.

DIMEROMYCES APHANOCEPHALI Thaxter. Plate X, figs. 259–261.

L. c. 55, 269.

Male individual colorless, or pale yellowish; the receptacle three-celled, the cells subequal, the upper long-oval tilted and externally prominent. Antheridium erect, the stalk-cell free externally, the short neck hardly divergent, hardly exceeding the tip of the appendage, which consists of two subequal cells, 15 × 3.5 μ. Antheridium 20 μ. Total length 35 μ.

Female individual colorless or yellowish. Receptacle and appendages sprawling on the substratum, the former four- or five-celled, the first four subequal, much broader than long. The subbasal cell giving rise to a short tapering secondary appendage on either side, one longer than the other, of seven or eight cells, the primary appendage undifferentiated and similar to the secondary: the short broad basal cell united to the basal cells of the two adjacent appendages, the shorter of which acts as a buffer. Perithecium with an elongate stalk, arising perpendicularly from the substratum, erect or strongly curved; the ascigerous portion moderately well distinguished, not quite symmetrical, slightly inflated, rather long and slender, terminating in a short, finger-like, erect projection, the lumen of the lower part of the stalk more or less obliterated.

Perithecium; stalk 90–170 × 10–11.5 μ; ascigerous portion 60–75 × 15–18 μ; total length 150–240 μ. Appendages 50–70 μ.

At the tips of the elytra of *Aphanocephalus pubescens* Gronv., No. 1834, Sarawak, Borneo.

In its sprawling habit this species resembles *D. appressus*, for which, in some positions, it might readily be mistaken. The form and characters of the receptacle and appendages are, however, quite different; as are the characters of the male. The latter is very simple in structure and its receptacle is perhaps better regarded as only two-celled, with a three-celled appendage not clearly distinguished from it. The antheridium appears to have but two antheridial cells, only one of which seems to be functional, and the species is perhaps better associated with *D. Tomari* and the other forms allied to *Eudimeromyces*. The production of opposite branches or secondary appendages from the subbasal cell of the female is unusual, the shorter branch acting as a buffer or support turned toward the substratum, and may approximate the condition seen in End. anomalus.

4. ON PHALACRIDAE.

DIMEROMYCES UNGUIPES Thaxter. Plate VII, figs. 183–184.

L. c. **55**, 258.

Male individual rather evenly tinged with pale brown, slender, erect; the foot long, slender and claw-like. Receptacle consisting of three cells; the basal much longer, but slightly broader distally, obliquely separated from the oblique, flattened subbasal cell, which separates a small cell below the base of the antheridium, which is erect, with relatively long narrow stalk; the venter abruptly broader distally; the neck short, gradually tapering from its broad base, and reaching somewhat above the tip of the appendage, toward which it is very slightly bent. Antheridium 38 × 9 μ. Receptacle, without foot, 34 × 8 μ. Appendage 27 μ. Total length to tip of antheridium 80–90 μ.

Female individual rather slender, suberect, its color like the male; the foot similar; the receptacle consisting of five cells; the basal much longer, nearly uniform below, distally obliquely separated from the three middle cells, which are flattened and very oblique; the fifth subtriangular. Primary appendage of three successively smaller cells, the distal more deeply suffused: secondary appendage arising from the third cell, below and beside the perithecium, of four cells, the basal longer than the three distal ones combined, of which the subterminal is the shortest, the distal paler. Perithecium straight, erect, slender, nearly symmetrical, broadest just below the tip, which, with the apex, is relatively short, subconical, tapering to the blunt, symmetrically rounded, or subtruncate, extremity; the sporiferous region finely transversely verruculose, or roughened, this modification extending downward less conspicuously nearly to the base of the paler undifferentiated stalk-region. Perithecium 135 × 16 μ. Secondary appendage 66 × 8.5 μ; primary 34 × 6 μ. Receptacle, without foot, 42 × 16 μ. Total length to tip of perithecium 180 μ.

On the elytra of *Eustilbus apicalis* Sharp, Agua Caliente, Guatemala, No. 1603.

The host on which this peculiar form was found was received from the late Professor Kellerman, who very kindly collected for me a number of miscellaneous insects, during his last trip to Guatemala. The material is very scanty, and only one female and two males in perfect condition are available. Its variation may therefore be greater than is indicated by the above description and more than one perithecium or secondary appendage may sometimes be produced. The subbasal cell cuts off a small cell below the single secondary appendage of the type, which may well, in some individuals, give rise to another appendage. Its claw-like foot, transversely roughened perithecium, the form of which is itself peculiar, the characters of its secondary appendage,

with its greatly elongated basal cell; as well as the structure of its slender male, with its peculiarly shaped antheridium, serve clearly to distinguish it from other described forms, to none of which does it appear to be nearly related.

5. ON CUCUJIDAE.

DIMEROMYCES AMETROTHECALIS Thaxter. Plate VIII, figs. 208–210.

L. c. 55, 265.

Male individual hyaline, or faintly yellowish. Receptacle three-celled; including the foot, roughly triangular, and bearing a two-celled, short, subulate appendage from its upper angle; and normally two antheridia from its upper side, arising from the smaller, nearly equal, subtriangular subbasal and terminal cells. Antheridia usually straight and symmetrical, the upper inclined against the appendage, the lower often slightly divergent; the stalk-cell short, but well distinguished; the venter stout, nearly symmetrical, extending above the tip of the appendage; the neck slender, straight, or less often slightly curved, subulate, relatively long. Receptacle, without foot, 21–22 × 9–10 μ. Appendage 13–17 μ. Antheridia 30–38 × 10 μ. Total length to tips of necks 63–66 μ.

Female individual pale yellowish, becoming tinged with brown. Receptacle relatively minute, consisting of four cells; the basal much larger; the rest successively smaller, subtriangular. Primary appendage short, three-celled, subulate; the secondary single, simple, arising from the subbasal cell, of nine or ten short cells, mostly broader than long, with slightly oblique septa; the whole tapering gradually to a point, and lying against the base of the perithecial stalk. Perithecium single, arising from the third cell, monstrously developed, becoming more or less deeply tinged with reddish brown; the stalk abruptly very broad above its origin, passing into the ascigerous portion without differentiation; the tip more clearly distinguished on the inner side, short and broad, the apex clearly distinguished, slightly bent outward, rounded. Perithecia 170–400 × 25–27 μ. Receptacle and foot 38–42 × 12–15 μ. Primary appendage 16–20 μ; secondary 40–60 μ. Total length to tip of perithecium 200–430 μ.

On the upper surface of the abdomen of *Cucujinus micromma* Arrow, No. 2339, Kamerun, West Africa.

This species, which is distinguished by its monstrously developed perithecium and minute receptacle, with its subulate primary appendage, does not appear to be nearly allied to any of the known forms. No other member of the genus is known to occur on Cucujidae.

6. ON CRYPTOPHAGIDAE.

DIMEROMYCES TOMARI Thaxter. Plate X, figs. 274–278.

L. c. 55, 272.

Male individual hyaline, the basal cell about as broad as long; the subbasal much smaller, bearing terminally a relatively stout undifferentiated appendage of three or four cells, and laterally a rather stout, short antheridium, its stalk-cell clearly defined, the antheridial cells apparently two, without basal cells; the neck short, stout and blunt: foot sometimes larger than the receptacle, which is 8.4 × 4.2 μ. Appendage 20 × 4 μ. Antheridium about 12 × 5 μ.

Female individual becoming faintly tinged with brownish yellow. Receptacle consisting of three or four cells; those above the larger basal cell more or less horizontally disposed, often somewhat irregularly displaced; the subbasal bearing a stout undifferentiated secondary appendage, sometimes as long as the perithecium, tapering slightly, the lower cells shorter; the third

or fourth cell followed by the primary appendage, which is similar to the secondary, though often shorter, usually of eight or nine cells. Perithecium arising from the third cell, long and relatively stout, the stalk sometimes as long as the ascigerous part, and even broader; erect, straight, or slightly curved below, somewhat asymmetrical; the tip and bluntly rounded apex slightly distinguished, rather short and slightly tapering. Perithecia 80–100 × 12 μ, longest 140 μ. Appendages 50–90 μ. Basal and subbasal cells 10.5 × 12.5 μ. Total length to tip of perithecium 90–150 μ.

On the elytra of *Tomarus bellus* Gronv., No. 2776, Grand Etang, Grenada, B. W. I.

The female of this species closely resembles that of *Eudimeromyces Chiliotis*, except for the presence of a secondary appendage, and it is not improbable that the apparent differences in the males of the latter are less fundamental than was at first supposed. In the present form the antheridia are in several instances clearly compound, and borne from the subbasal cell below the appendage, as in figures 227 and 228. In several, however, that are in place next the female, the antheridium might be terminal: but as it is almost impossible to isolate them, from the fact that they are hyaline and very minute, it has not been possible to be certain of their exact structure. Although I have chosen to retain the genus Eudimeromyces *ad interim*, it is evident that the three species on minute Cryptophagidae herewith enumerated, namely *D. aberrans*, *D. Tomari* and *E. Chiliotis*, are very closely allied, and very probably congeneric: but a definite decision as to this point must await the examination of more abundant material. The present species is much less complicated than the nearly allied *D. aberrans*, since it does not appear to produce the accessory perithecia, which make the homologies of the receptacle, in the latter, so difficult to interpret.

Dimeromyces aberrans Thaxter. Plate X, figs. 282–285.

L. c. **55**, 270.

Male individual consisting of a small basal and subbasal cell, the latter bearing distally a bluntly pointed terminal cell, and subterminally a short-stalked antheridium; the neck of which is very short and blunt, or nearly obsolete; the antheridial cells apparently two; the subbasal cell sometimes producing one or more branches; which consist of a basal cell, bearing distally a bluntly pointed cell, and subterminally a short-stalked antheridium. Total length about 30 μ. Antheridium and stalk 11 × 3.5 μ.

Female individual pale yellowish, more or less bilaterally symmetrical in general habit; the broad short basal cell for the most part blackened, and indistinguishable from the foot; overlapping the small subbasal cell, which produces, right and left, what have the appearance of similar branches; rather closely septate, often thicker distally, curved upward outside the perithecia, which subtend them on the inner side: one of these branches, the secondary appendage, usually somewhat longer and stouter than the other, which corresponds to the primary appendage: the first perithecium arising from the third cell of the receptacle, at the base of the latter; the basal cell of which is not distinguished from it: the basal cell of the secondary appendage, also, usually giving rise to one, or even two, perithecia. Perithecia seldom more than four, sometimes only one: asymmetrical, straighter on the inner margin, usually nearly twice as long as the appendages, irregularly fusiform; the stalk-portion relatively short, and tapering to its narrow insertion, not distinguished from the gradually much broader ascigerous portion; which is slightly bent inward distally, strongly convex externally and distally, the inner margin distally even slightly concave: the apex sometimes very slightly and abruptly bent upward, distally broad and flat, or blunt. Perithecia 55–75 × 13 μ. Appendages 30–48 × 6–7 μ. Total length to tip of perithecium 70–92 μ.

On the elytra of *Tomarus atomarius* Sharp, or closely allied species. No. 1527, Columbus, Ohio; No. 1609, Los Amates, Guatemala; No. 1599, El Rancho, Guatemala.

The hosts bearing this curious parasite were collected for me by the late Professor Kellerman, to whom I am indebted for numerous other new and interesting forms. The species is most nearly allied to *D. Tomari*, from which it differs in the form and number of its perithecia and appendages. Although its pseudobilateral habit gives it a very different appearance, it does not appear to differ fundamentally from other somewhat aberrant types of the genus. A corresponding development of accessory perithecia is found in *D. Peltoidis* and *D. adventitiosus*, and the production of secondary branches bearing antheridia, which, however, does not always occur in the present species, finds a parallel in *D. Thaxteri*, *D. adventitiosus* or *D. eximius*. The males are so small, and adhere so closely to the base of the female, that they can only be separated with the greatest difficulty. Nevertheless, a few have been clearly seen, as in figures 284–285. The antheridium, though not unlike that of *D. Tomari*, is not typical; the neck being but slightly developed, and the antheridial cells apparently only two in number. The individual necks of the antheridial cells seem hardly to discharge their sperm cells into a common cavity and tube, but almost directly to the outside. They are so small, however, and their definition is so vague that it has not been possible to determine this point with certainty.

Dimeromyces necrotalis Thaxter. Plate VII, figs. 178–179.

L. c. 55, 257.

Male individual (type specimen) pale yellowish, the receptacle of four obliquely superposed cells, the two middle much flattened. Basal cell short, triangular, protruding beyond the base of the lower antheridium. Appendage straight, rigid, tapering, distally attenuated, concolorous, the basal cell about as long as the subbasal, which is rather abruptly somewhat narrower. Antheridia stout, the stalk short and well defined; the short stout venter rather abruptly distinguished from the broad base of the rather short, slightly tapering, straight neck. Appendage 35 μ. Antheridium 20 × 6 μ. Total length to tip of appendage 55 μ. Receptacle 20 × 10 μ.

Female individual pale yellowish throughout; the receptacle of ten cells, the basal extending horizontally to the base of the lowest secondary appendage; the rest of the receptacle a horizontal series of cells, all, except the eighth and ninth, wedge-shaped with points downward; the terminal cell larger, subtriangular, externally abruptly prominent below the base of the primary appendage, which is similar to, but slightly stouter and somewhat shorter than, the secondary appendages; which tend to alternate with the perithecia, diverging slightly from one another, straight, ridged, tapering throughout to a slender extremity, of seven or eight cells, the whole forming, with the receptacle and considerably longer alternating perithecia, a fan-like structure. Perithecia straight, the stalk well developed and rather clearly distinguished from the somewhat shorter sporiferous portion, which is nearly symmetrically subfusiform, the distal half with two or three slight marginal depressions and elevations, the upper distinguishing the tip rather clearly; the apex well defined, about as long as broad, distally rounded. Perithecia 106 × (stalk) 8 × (sporiferous part) 15 μ. Longer appendages 75 × 7.5 μ, at base. Horizontal receptacle 35 × 10 μ.

On the antennae of *Necrota africana* Gr., Kamerun, West Africa, No. 2577.

A mature female and one in which the trichogynes are still adherent, together with a single male, all in perfect condition, have been examined. In the latter, figure 179, the third antheridium is still unicellular, and in the female, but one perithecium is fully mature, figure 178. The species is of great interest, since the structure and development of its receptacle partake of the characters of both the genus *Dimorphomyces* and *Dimeromyces*. Although the basal cell re-

mains in contact with four or five of the cells last separated from it, the interposition of an equal number of cells between it and the base of the primary appendage clearly distinguishes it from any type found in *Dimorphomyces*. For further reference to the characters of this species vid. sub DIMORPHOMYCES, p. 11.

7. ON CLERIDAE.

DIMEROMYCES CORYNETIS Thaxter. Plate VII, figs. 196–197.

L. c. **48**, 157. Spegazzini, Ann. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 514, fig. 55.

Male individual pale yellow, the axis straight, erect. Receptacle of three to eight cells; the basal larger, subtriangular; the rest successively slightly larger from below up, small, flattened, horizontal, each producing an antheridium diverging at right angles from the axis. Primary appendage a single very large mitriform cell, its base broader than the receptacle, somewhat inflated, nearly symmetrical. Antheridia two to seven, relatively very large, the stalk-cell sometimes half the total length, narrow below, broader distally, but clearly distinguished from the broader stout venter, which is considerably inflated, subsymmetrical or slightly more prominent, distally, below; the straight neck abruptly distinguished, as long as, or slightly longer than, the venter, tapering evenly from its broad base to its rather truncate apex. Total length about 50–60 × 9 μ. Appendage 14–20 × 10–12 μ. Antheridia about 35 μ; the stalk-cell 9–18 × 6 μ; the venter 10 × 12 μ.

Female individual pale yellow, or faintly tinged with brownish. Receptacle similar to that of the male, of four or five cells, and terminated by a similar appendage: the distal cell bearing a secondary appendage, erect or somewhat divergent, of five or six successively smaller slightly inflated cells; the first perithecium arising from the cell immediately below it, and one or even two more very rarely developed from the cells immediately below the first. Perithecium usually single, relatively very large, usually curved slightly throughout, or more abruptly at the base, variably divergent, the stalk well developed, but not clearly distinguished, shorter than the rest, which is broader below the tip; the latter short and broad, fairly distinguished, as is the short broad apex, the broad blunt extremity of which is often slightly sulcate. Spores 60 × 9 μ. Perithecia 150–215 × 30–40 μ, 100–135 μ above the stalk-portion. Appendage 60–100 × 8 μ. Receptacle, to tip of primary appendage, 80–100 μ.

On the elytra of *Corynetes ruficollis* Fabr. La Plata, Argentina, No. 1459; No. 2798, Honolulu, Hawaii.

The host of this species being more or less cosmopolitan, it is probable, from its occurrence in the Hawaiian Islands, whence it has been sent to me by Dr. A. T. Speare, that the parasite is also widely distributed. It is one of the most clearly defined of the known members of the genus, and is most readily distinguished by its unicellular mitrate appendage. The axis appears to lie flat on the surface of the host, and the antheridia and perithecia project upward from it nearly at right angles. The species has been again found by Spegazzini in the Argentine. It does not appear to be nearly related to other forms.

8. ON ENDOMYCHIDAE.

DIMEROMYCES TRYCHERI Thaxter. Plate IV, figs. 105–108.

L. c. **55**, 238.

Male individual pale yellowish. Receptacle rather stout, consisting of six to eight cells, somewhat oblique and flattened, except the basal and distal: appendage straight, characteristically divergent, its three cells nearly equal in length, the basal slightly broader. Antheridia two to six,

radiately divergent; the stalk short, broad and well defined; the venter rather broad distally; the base of the neck abruptly distinguished, but relatively large and broad; the distal part about equal to it in length, straight, uniform, truncate. Receptacle about 30 × 12 μ. Appendage and antheridia 25–30 μ, the latter × 8 μ.

Female individual pale yellowish. Receptacle consisting of more often sixteen cells, the basal subtriangular, the rest usually much flattened, especially the lower; those of the upper half somewhat oblique, all, except one or two of the lowest, bearing perithecia or secondary appendages more or less alternating. Primary appendage of three or four cells, short, divergent; the subbasal abruptly narrower than the basal and suffused with pale brownish: secondary appendages four to eight or nine, much longer, of four to eight or nine cells; the two basal short and broad, the third abruptly slightly narrower and conspicuously tinged with brown; the upper radiately divergent, slightly tapering; the lower three or four not thus modified at the base, and often characteristically curved downward and even across the foot, not associated with perithecia, more evenly tapering. Perithecia alternating with the upper three to seven appendages, mostly straight, subsymmetrical and subfusiform, the stalk not distinguished, and shorter than the sporiferous portion; the tip large and well distinguished, slightly and subsymmetrically inflated; the apex well distinguished, very slightly inflated, nearly symmetrical, distally rounded, with a slight median apiculus. Perithecia 100–125 × 25 μ. Receptacle 80–100 × 25–30 μ. Primary appendage 30–40 μ; secondary, longer, 85–100 × 9 μ.

On the elytra and legs of *Trycherus bimaculatus* Guer., No. 2445, (Type) and 3087: of *Trycherus* sp., No. 3088. Metet, Kamerun, West Africa.

This species is most nearly allied to *D. Strongylii* and *D. Amarygmi;* but although somewhat variable, is easily distinguished by the conspicuous brown suffusion of the third cell of its secondary appendages. In the type, the receptacle is distally curved, as in figure 105. The individuals from No. 3088, which grew on the legs, are much stouter, as is usually the case in this position, and may be straight and very broad, even more so than is shown in figure 106. The appendages are also shorter, for the most part, and the lower ones show less tendency to bend downward.

Dimeromyces Platycillibis Thaxter. Plate VIII, figs. 201–204.

L. c. 55, 269.

Male individual pale yellowish, tinged with brown. Receptacle straight, erect, of five or six cells; the basal longer, subtriangular; the rest somewhat flattened, the middle ones broader. Appendage of three cells, the basal and subbasal subequal, the latter roundish and distinguished above, and less broadly below, by darker brown or blackish shades, the distal cell somewhat tapering and longer. Antheridia one to three, strongly divergent; the stalk-cells small and almost included; the venters short and stout, rather abruptly distinguished from the outcurved, tapering necks. Length to tip of appendage 38–48 μ. Antheridia 15–18 × 7.5 μ.

Female individual yellowish, rather strongly tinged with brownish at maturity. Receptacle nearly straight and erect, of five to eight cells; the basal short, subtriangular, much larger; the rest flattened, the upper somewhat oblique; primary appendage relatively very small, similar to that of the male; the secondary appendage usually single and subterminal, a second sometimes arising below the perithecium; consisting of a basal portion of six to nine cells, but slightly if at all longer than broad, distinguished by a constriction, associated with a deeper brown suffusion, from a terminal portion of one to several cells, variably elongated and slightly tapering, the walls often disorganized. Perithecia somewhat more distinctly brown, rather short and stout, broader below the tip, which is not distinguished, except that it tapers rather abruptly to the broad, blunt, undifferentiated apex: nearly sessile, or the stalk sometimes distinguished. Spores

20–24 × 2.5 μ. Perithecia 58–68 × 20 μ. Receptacle, without foot, 25–28 μ. Primary appendage 15–28 μ; secondary 45–85 × 10–12 μ; terminal part 45–130 μ.

On the upper surface of *Platycillibe* sp., No. 2986, Wainoni Bay, Solomon Islands, M. C. Z. (Mann Coll.).

This species is perhaps more nearly allied to *D. Trycheri* than to other known species, and is easily distinguished by its very small primary appendage, and the character of the secondary appendages, with their very clearly distinguished basal and terminal portions. The latter vary considerably, both in length and in the number of cells composing them, of which there may be but one, and usually taper above a slightly swollen base.

9. ON TENEBRIONIDAE.

Dimeromyces brachiatus Thaxter. Plate III, figs. 72–74.

L. c. **51**, 6.

Male individual hyaline, subtriangular above the stalk-like base of the basal cell, the lumen of which is obliterated above the large foot. Receptacle of from five to seven cells, the distal larger; the basal much larger than the cells between them, which are irregularly flattened and very oblique; the lumen of the basal small and subtriangular; the distal cell somewhat prominent externally, bearing the single antheridium and the terminal primary appendage: the latter rather short, suberect, its abruptly smaller hyaline, squarish, or somewhat flattened, basal cell followed by two slightly broader, brownish, somewhat flattened; the terminal cell hyaline, long, hardly tapering, with rounded extremity. Secondary appendages three or four, arising from the cells below the antheridium, parallel and closely associated, with a divergence of about 45°, similar to the primary, with sometimes three short brown cells, the basal cell being sometimes twice as long as broad. Antheridium with a well defined stalk-cell, distally bent strongly sidewise, the distal portion of the neck at right angles. Receptacle 46 × 12 μ. Foot 18 μ. Appendages 28 × 4 μ. Antheridium 27 or more ×9 μ.

Female individual, hyaline or faintly yellowish. Receptacle similar to that of the male, consisting of eight or nine cells flattened or wedge-shaped, somewhat radiately disposed; the distal cell subtriangular, and bearing the small strongly divergent primary appendage, which is similar to that of the male, though less well developed. The cells of the receptacle also giving rise to three different structures, one or two perithecia, always from the subterminal cell, and often from the third cell below it; a secondary appendage similar to the primary, but better developed, always from the cell below the first perithecium; and normally three secondary sterile axes from the terminal cell and the fourth and sixth cells below it: or the cells immediately below the secondary appendage producing secondary axes, or perithecia, without regularity. Secondary axes very greatly elongated, flattened, of nearly equal width throughout, the walls very thick, the lumina of the small cells disposed more or less regularly in vertical pairs, right and left, each pair associated with straight, appressed appendages, which alternate on either side, and are similar to those of the male. Perithecia arising from a short basal cell, similar to that which subtends the secondary axes, mostly erect, distally somewhat broader, thence tapering slightly to the short, slightly broadened, somewhat symmetrically rounded apex; the lips slightly prominent. Peritheica 90–120 × 15–20 μ; the basal cell 12 × 8 μ. Receptacle 50–60 × 20 μ; the foot 20 μ. Primary and secondary appendages 18–22 × 4 μ Secondary axes up to 580 × 12 μ, their appendages 20–28 × 4 μ.

On the elytra of *Heterophaga* sp. nov., No. 2107, Peradeniya, Ceylon.

This, the most remarkable form in the whole genus, is very clearly distinguished by its peculiar sterile secondary axes, no other species having structures which seem closely com-

parable, unless it be the fertile-secondary axes of *D. crispatus*. The perithecium, in the present instance, may be regarded as borne on a unicellular fertile axis; since the basal cell subtending it may produce one, or even two, secondary perithecia, if the first is injured or fails to develop. Owing to the abrupt distal curvature of the antheridium, it is not possible to determine its characters very satisfactorily. There appear to be four or more antheridial cells, but a reexamination of individuals which have become more transparent by over ten years' immersion in glycerine makes it seem doubtful whether there are eight as originally described. The host which has been determined by Mr. Champion as a new species of Heterophaga, allied to *H. nitidula* Motsch., was found among a miscellaneous collection of insects for which I am very greatly indebted to Mr. T. Petch.

Dimeromyces Derispiae Thaxter. Plate IV, figs. 103–104.

L. c. **55**, 243.

Male individual pale yellowish. Receptacle consisting of from five to seven cells; the basa- longer narrow below; the rest somewhat oblique, and flattened, except the distal. Primary apl pendage consisting of a stouter basal cell, twice as long as broad, and a somewhat more slender, three-celled, bluntly tipped distal portion, which converges parallel to the slightly divergent antheridia, the tips of which it slightly exceeds; its middle cell usually shorter than the other two. Antheridia two to four, superposed, somewhat divergent, the stalk-cell small, enclosed; venter strongly convex externally; base of neck broad, tapering, longer than the distal part, slightly curved outward. Receptacle 55–57 × 12.5 μ. Appendage 34–42 μ. Antheridia 25–29 × 9–12.5 μ. Total length to tip of appendage, including small pointed foot, 80–92 μ. Appendage 34–42 μ.

Female individual yellow, becoming slightly tinged with brown, straight, erect. Receptacle with small pointed foot, consisting of about twelve to sixteen cells; the basal subtriangular, somewhat longer than broad; those immediately above short, and much flattened, non oblique; the rest becoming oval or elliptical in outline, their posterior margins rather strongly convex, all but the lowest separating a small cell distally and externally: the subterminal (and rarely the second cell below it) giving rise to a slightly tapering, outcurved, seven- to ten-celled appendage; slightly shorter than the similar, erect, six- or nine-celled terminal primary appendage: the two forming a fork between which the slightly shorter perithecium is inserted. The latter erect, nearly symmetrical, subfusiform, sessile, relatively short; the tip relatively long, well distinguished, more convex anteriorly; the apex short, rounded. Perithecia 105 × 22 μ. Receptacle 125–170 × 25 μ. Primary appendage 90–125 × 12 μ; secondary 80–95 μ. Total length to tip of perithecium 210–275 μ.

On the left elytron of *Derispia Moquerysi* Pic., No. 2568, Kamerun, West Africa.

A clearly defined and peculiar species, which, in general appearance, bears a remote resemblance to *D. nanomasculus;* although the perithecia and secondary appendages are unilateral. Rarely a second perithecium and appendage may arise below that first formed, but this appears to be rather the result of injury. The convergence of the male appendage, above its basal cell, appears to be quite characteristic.

Dimeromyces Gonocnemalis Thaxter. Plate VIII, figs. 198–200.

L. c. **55**, 261.

Male individual erect, more or less slender; receptacle of from two to five cells, those above the longer larger basal cell subequal, slightly oblique, somewhat broader than long. Primary

appendage consisting of four to five successively somewhat smaller cells, distally more or less conspicuously enlarged, and tinged with brown, except the terminal one. Antheridia one to three, slightly divergent, straight, the stalk long, slender and hyaline, the neck and venter more or less tinged with purplish brown; the latter somewhat asymmetrical, more abruptly convex externally, the neck straight, tapering considerably, almost subulate. Receptacle 34–50 × 9 μ, the stalk 20–22 μ; the antheridia and appendage usually slightly divergent.

Female individual very variable in size. Receptacle usually curved strongly backward; hyaline to pale yellowish, the upper half or more becoming rather deeply tinged with reddish brown; consisting of eight to sixteen cells, more or less, the lower much flattened, oblique, owing, only, to the general curvature. Primary appendage not abruptly distinguished, soon broken, consisting of six or seven cells, the two or three lower becoming brownish, deeper and contrasting distally. Secondary appendages two or three to ten, longer, tending to alternate with the perithecia, erect and rather rigid, or somewhat flexuous; two to four or more of the terminal cells often abruptly somewhat smaller; the lower cells, in older appendages, sometimes marked by faint, scattered darker patches; the cells eighteen, more or less, many of them somewhat abruptly broader distally, with slightly concave margins. Perithecia one or two to eight, more or less; the stalk well developed, elongate; but not usually clearly distinguished from the ascigerous portion; which becomes rather deep red-brown, the stalk yellowish, or becoming tinged with pale brown; the whole straight and rigid, or slightly sigmoid, tapering distally to the undifferentiated tip and blunt apex. Largest perithecia 300 × 25 μ; ascigerous portion about 140 μ, but varying to much smaller dimensions. Receptacle about 60–80 × 15–20 μ. Primary appendage 125–170 × 12 μ; longer secondary appendages 300–425 μ, more or less.

On the elytra of *Gonocnemis* sp., Nos. 2356 and 2633, Kamerun, West Africa.

This species is very nearly allied to *D. maculatus* and may show a much fainter though similar maculation of the secondary appendages; which are stouter, the cells tending to be distally enlarged, with slightly concave margins. The receptacle is very different from the subtriangular compact habit seen in *D. maculatus*. The male also is dissimilar, having a primary appendage of different form, and antheridia of peculiar outline, unassociated with secondary appendages.

Dimeromyces Peltoidis Thaxter. Plate III, figs. 68–71.

L. c. **55**, 235.

Male individual hyaline, becoming slightly tinged with brown, four- or five-celled, the basal larger and much longer, sometimes partly involved by the blackening of the foot. Appendage undifferentiated, of two or three cells, slightly tapering, rarely once-branched. Antheridia slightly divergent, usually two or more, rather short and stout, especially the neck, which is bluntly subconical, or but slightly curved. Total length 40–46 μ. Antheridia 15–20 × 4.5–5.5 μ.

Female individual pale yellowish, or becoming tinged with brown, variable. Receptacle short and somewhat stout, straight and erect, or curved; the basal cell larger and longer than the rest, which are more or less oblique and wedge-shaped; each producing one, or rarely two, perithecia or appendages, or one of each. Primary appendage simple, or furcate above the smaller undifferentiated basal cell; somewhat moniliform, or the rather numerous cells squarish or subrectangular; secondary appendages similar, often furcate above the basal cell, which is not distinguished and may also produce an accessory perithecium between the branches. Perithecia large, long, subsymmetrical; the stalk often slender and well developed, not always clearly distinguished from the sporiferous portion; the tip large, well distinguished, rather character-

istically swollen, tapering distally to the short, bluntly rounded, undifferentiated apex. Spores 26 × 2.5 μ. Perithecia 85–180 × 14–22 μ. Longest appendages 100–190 × 6–9 μ. Receptacle 38–46 × 4.5–5.5 μ.

On *Peltoides pustulatus* Fairm., No. 3080, Kamerun, West Africa.

This species, which appears to be somewhat allied to *D. adventitiosus* and *D. anomalus*, varies very considerably according to its position and luxuriance of growth. Individuals from the legs, and the tip of the abdomen, are darker and more fasciculate, with shorter perithecia. Those on the elytra and prothorax are simple and smaller, the appendages usually simple and single. A specimen growing near the base of the posterior legs, figure 68, is much larger, with several supernumerary perithecia, and branched appendages, a perithecium and an appendage also arising independently from the distal cell of the receptacle. The occurrence of furcate appendages bearing perithecia has been referred to above, p. 333, and might suggest that secondary perithecigerous branches from the receptacle, such as occur in *D. crispatus*, may be merely modified secondary appendages. In the more compact and fasciculate individuals the cells of the receptacle may be so crowded that it is not possible to distinguish them clearly, or the origins of the tuft of appendages which arise from them, as from a common base.

Dimeromyces Amarygmi Thaxter. Plate IV, figs. 111–112.

L. c. **55**, 237.

Male individual hyaline, or faintly yellowish, rather slender, erect; the receptacle consisting of about ten cells, more or less; the basal much larger; the rest flattened, small, the upper somewhat oblique; the distal and one to six of the cells below it, giving rise to antheridia, which are suberect, or not strongly divergent; the stalk-cell free, and clearly defined; the neck as long as the venter, strongly bent outward. Primary appendage simple, stouter below, distally tapering, usually longer than the receptacle. Antheridia 25–30 × 7–8 μ; receptacle 45–55 × 7–12 μ. Primary appendage 55–85 μ.

Female individual pale yellowish. Receptacle erect or slightly bent outward distally; consisting of from ten to eighteen cells; the basal larger subtriangular; the rest flattened, increasingly oblique distally, giving rise to perithecia, or rather rigid, simple, secondary appendages which alternate with them, at least above, where the latter may be greatly elongated and attenuated; while below they may be successively shorter, and less tapering, like the primary appendage, and bent abruptly toward the substratum. Perithecia one to several, usually subtending secondary appendages, suberect, straight, nearly symmetrical, increasing in diameter slightly and continuously from the insertion of the stalk to the region of the tip; which is clearly distinguished by slight elevations on either side, whence it tapers rather abruptly to the slightly inflated apex. Perithecia 125–235 × 20–24 μ, the subconical extremity about 20 μ. Longest appendages 150–275 μ. Receptacle 65–100 × 20–25 μ.

On the elytra of *Paramarygmus* sp., Nos. 2333 and 2567, Kamerun, West Africa.

This fine species is allied to *D. Strongylii*, and even more closely to *D. Trycheri*, from which it is distinguished by the form of its perithecium, and the unmodified bases of its much longer upper secondary appendages.

Dimeromyces Strongylii Thaxter. Plate IV, figs. 109–110.

L. c. **55**, 236.

Male individual pale yellowish, with a faint tinge of brownish. Receptacle compact, erect, slightly curved; of five to twelve cells, slightly tapering above the subbasal; the basal short,

angular, or similar to the rest; which are subsimilar, flattened wedge-shaped, oblique; the distal usually separated by a more or less abrupt indentation from the basal cell of the erect appendage; which consists of usually four cells, tapering to a point, the basal cell somewhat inflated, longer than broad; the terminal ones projecting from a collar formed by the ruptured outer wall-layers above the subbasal cell. Antheridia from three to ten, often six, subradiate, short and stout; the stalk-cell distinct; the venter rather abruptly distinguished from the base of the neck, which is stout and abruptly distinguished from the short, straight, uniform and truncate distal part: the successive antheridia diverging slightly right and left, and often associated with one or two secondary appendages; which are similar to the primary, but often longer, their basal cells not inflated. Receptacle 25–42 × 16 μ. Antheridia 25–30 × 9 μ. Appendages 40–80 μ.

Female individual similar to the male. Receptacle of eight to ten cells, producing one or two to four perithecia, usually alternating with secondary appendages; which are usually longer than the primary, projecting beyond the perithecia, tapering; the five or six basal cells below the collar stouter, twice as long as broad, or less, sometimes slightly inflated: the whole rather stiff and straight, or but slightly curved or bent; the axis of each appendage, as well as of the perithecia, more or less coincident with the transverse axis of the cell of the receptacle which bears it. Perithecia subfusiform, straight, subsymmetrical, the stalk not abruptly distinguished, and about as long as the ascigerous portion; the termination blunt, rather broad, unmodified. Perithecia 75–120 × 20–25 μ. Receptacle 40–60 × 16–25 μ. Longer appendages 100–150 μ.

On the elytra and inferior surface of species of an unknown genus near *Menephilus* (fide Arrow), No. 2353, (Type), No. 2569, Kamerun, West Africa. On *Platydema detersum* Walk., No. 2122, Sarawak, Borneo.

The host on which the type of this species was originally found was determined for me as *Strongylium* sp.; but Mr. Arrow has since informed me that it belongs to an unknown genus near *Menephilus*. Individuals from Borneo have appendages with somewhat more numerous and shorter cells, separated below by more distinct constrictions; but the differences are unimportant. The few individuals from host No. 2569, however, differ in having more erect, elongate and straighter receptacles, and suberect perithecia and appendages. This form possibly may not belong here, but the material is not sufficient to determine this definitely. The species is most nearly allied to *D. Trycheri*, *D. Amarygmi*, *D. Peltoidis* and *D. adventitiosus*, from all of which it is, however, abundantly distinct.

Dimeromyces adventitiosus Thaxter. Plate III, figs. 64–67.

L. c. **55**, 233.

Male individual pale yellowish, the receptacle consisting of five or more cells; the basal larger, subtriangular, the rest somewhat flattened and oblique; producing single, slightly divergent antheridia, or occasionally simple sterile branches. The primary appendage an undifferentiated continuation of the axis; often bearing numerous antheridia on one or both sides; a large secondary appendage sometimes developed from the subbasal cell, of indefinite growth, and producing numerous antheridia from the upper margin. Antheridia straight, or the necks slightly curved; the stalk-cell well distinguished. Length of receptacle proper about 25 μ. Primary appendage 40 μ or more, sometimes over 200 μ; the large secondary appendage somewhat shorter. Antheridia about 22 × 5 μ.

Female individual pale yellowish; the receptacle consisting of six to eight somewhat flattened and oblique cells, the basal triangular; the primary appendage often greatly elongated, undifferentiated. Three or four of the cells of the receptacle usually producing simple, undifferentiated secondary appendages; while from one or more of the remainder, perithecia may develop;

adventitious perithecia often arising also from the lower secondary, as well as the primary, appendage. Perithecia straight, somewhat asymmetrical, the stalk-portion short and not clearly defined, one margin more strongly convex; tapering distally to the short, nearly symmetrical, rather clearly distinguished, small, blunt apex. Perithecia 80–110 × 20–18 μ. Receptacle and foot 40 μ or less. Appendages variably elongated, up to 425 × 9 μ.

On the elytra and prothorax of *Tenebrio quadrihamatus* Fairm., No. 2801B, M. C. Z., Madagascar (Wulsin).

Reference has several times been made above to the very unusual conditions presented by this species, owing to the development of adventitious antheridia and perithecia, of which figure 67 illustrates an extreme case. The material is not very abundant, and it is not unlikely that female individuals may occur in which the adventitious perithecia are more numerous than in any of those examined. Not more than three have been seen on a single appendage, though they may develop not far from the extremity, as in figure 65. Many individuals of both sexes are quite normal. The pairs are scattered on the upper surface of the host, and are seen with considerable difficulty. The species is most nearly allied to *D. anomalus*, which also occurs on a tenebrionid, and shows a somewhat similar tendency to produce adventitious antheridia, and probably, also, perithecia; although the material, in this instance, is also too scanty to show the range of variation in this respect.

Dimeromyces anomalus Thaxter. Plate III, figs. 61–63.

L. c. **55**, 234.

Male individual pale yellowish, the axis rather slender and consisting of an indeterminate number of cells, of which there may be ten or more; slightly tapering; the primary appendage not distinguished; the subbasal cell giving rise to a secondary appendage, which is very similar to the main axis, the two diverging, so that the individual has a furcate habit; any cell of these axes bearing antheridia from the upper side, so that there may be six or more produced. Antheridia rather stout, with short well defined stalk-cells; the necks well distinguished, short and stout, somewhat curved; including stalk 20 × 6 μ. Longest axis 66 μ.

Female individual pale yellowish; Y- or T-shaped owing to the production of a secondary appendage from the subbasal cell, which curves away from and is more or less symmetrical with, the main axis; which is hardly larger, furcate above its basal cell; the basal cell of one of its branches sometimes producing a perithecium; the cell-relations sometimes confused by secondary divisions of the subbasal cell; the main axis giving rise to one or more perithecia and appendages, usually but one, the latter furcate above the basal cell: the cells of the axis and branches slightly longer than broad, the latter tapering but slightly. Perithecia usually not more than one to three, the stalk rather slender and well developed, rather clearly distinguished from the ascigerous portion; which is asymmetrical, more convex on one side, the apex flaring or asymmetrical. Perithecia 95 × 15–16 μ, ascigerous part 47–52 × 16 μ. The divergent axes 85–95 × 6 μ.

On the left elytron of *Platydema* sp., No. 3995, Florida, Solomon Is. (Mann).

Although the material of this species is scanty and in poor condition, the only individuals with mature perithecia being those represented in figures 61 and 62, it is so well marked and peculiar that it should be readily recognizable. Like *D. adventitiosus*, which is its nearest ally, and to a less degree *D. Peltoidis*, it is remarkable for the production of adventitious perithecia, as well as antheridia. Of the four males which have been examined, all show the same furcate habit, and production of antheridia from both the primary and secondary axes, while in *D. adventitiosus* individuals producing a secondary appendage, or axis, bearing antheridia, as in figure 67, are less frequent than the normal type shown in figure 66.

Dimeromyces amazonicus Thaxter. Plate IV, figs. 88–90.

L. c. **55**, 240.

Male individual hyaline, erect, slender, the receptacle consisting of three cells obliquely superposed, the basal longer; but slightly narrower below. Primary appendage three-celled, tapering to a point, the cells of about equal length. Antheridium relatively large and slender, nearly erect, the free stalk-cell bent abruptly upward; the neck nearly as long as the venter, slightly divergent, considerably exceeding the tip of the appendage. Total length to tip of antheridium 42 × 8 μ. Antheridia 24 × 9 μ. Appendage 14 × 3 μ.

Female individual hyaline, slightly curved. Receptacle consisting of four cells very obliquely superposed, so that the distal (outer) margins of the first three nearly coincide horizontally; the subbasal bearing the single secondary appendage, close to the base of which the third cuts off a small cell; the fourth less flattened, narrower and longer, bearing the single perithecium: the foot blackened only along its marginal contact. Primary appendage consisting of two rather abruptly broader basal cells, the upper longer, and an abruptly slender distal portion, brownish below, slightly tapering and variably elongated. The secondary appendage usually longer, consisting of a relatively large nearly free basal cell; above which a brownish, isodiametric, closely septate lower portion, of six to ten flattish cells, is rather abruptly distinguished; the distal portion above, variably elongated, the walls tending to disorganize distally. Perithecium sessile, or very short stalked, slightly curved, the inner margin rather strongly convex; the apex somewhat sulcate, distinguished from the undifferentiated tip by an abrupt constriction. Perithecia 60–75 × 14 μ. Longer appendage, secondary, 114–130 × 4 μ below; primary appendage 75–100 × 3.5 μ above basal cells which together are 24 × 6 μ. Receptacle 28 × 15 μ. Total length to tip of perithecium 75–100 μ.

On the elytra of *Platydema* sp.?, No. 2243, Independencia, Amazon (Mann Coll.).

This species, the host of which is not certainly determined, is clearly distinguished by the peculiarities of its appendages and the apex of its perithecium. One or two aberrant males have been seen with more than one antheridium. The large somewhat inflated lip-cells, which form the apex, and are abruptly distinguished, may be separate and somewhat divergent. The species appears to be more nearly allied to *D. sulcatus* and the other species which occur in the East on *Leiochrodes*.

Dimeromyces Cryptici Thaxter. Plate IV, figs. 100–102.

L. c. **55**, 239.

Male individual uniformly pale yellowish, becoming faintly tinged with brown. Receptacle and appendage forming an undifferentiated axis, tapering and somewhat divergent distally; the walls thick, the transverse septa nearly horizontal, the lower cells slightly flattened. Antheridia one to four, slightly divergent; the well developed stalk-cell bent abruptly upward; the venter short and stout; the hyaline neck straight, rather short, abruptly distinguished. Total length to tip of appendage 70 × 9 μ. Antheridia 25 × 8 μ.

Female individual similar to the male in structure and color, slightly darker. Subbasal cell of the receptacle giving rise to a stout, slightly tapering secondary appendage, curved upward against the lower perithecium, and reaching about to its middle. Perithecia one to several, subsymmetrically fusiform, erect, the short stalk bent abruptly upward; the tip hardly distinguished; the apex small, short, hyaline, abruptly distinguished by a slight constriction on both sides, accentuated by a protrusion on the inner side, slightly pointed and bent inward, with flat

rounded lips on either side. Perithecia 75–84 × 18–22 μ. Secondary appendage 75–90 × 9 μ. Total length to tip of primary appendage 75–100 × 9 μ, of perithecia 100–120 μ.

On the elytra of *Crypticus scriptipennis* Fairm., No. 3078, Kamerun, W. Africa.

Although this form is without striking individual peculiarities, it is well distinguished by its undifferentiated primary appendage, and its single secondary appendage, which curves up against the lower perithecium, and is very similar to the primary axis. The tips of the nearly symmetrical perithecia are rather characteristic from the slight constriction which distinguishes the apex, and the conformation of the latter.

Dimeromyces Heterophylli Thaxter. Plate IV, figs. 91–94.

L. c. **55**, 241.

Male individual hyaline, becoming tinged with pale brownish yellow. Receptacle consisting of four cells, the basal much longer; the rest somewhat flattened and obliquely superposed. Appendage of usually four cells, the basal much larger, and usually abruptly prominent, distally and externally, below the usually three-celled, abruptly narrower distal portion; which usually converges inward, its basal cell slightly brownish. Antheridia short and stout, sessile, with short necks, curved strongly outward. Receptacle and foot 30–35 μ. Appendage 20 μ. Antheridia 18 × 7.5 μ.

Female individual tinged with pale brownish yellow. Receptacle consisting of usually six or seven cells, flattened and oblique, except the basal, and the distal, the latter not distinguished from the basal cell of the primary appendage, which is bent against the perithecium, and similar to that of the male, but consists of from five to seven cells. Secondary appendage usually single, arising from the cell next below the insertion of the perithecium, the cells immediately below it separating small cells distally and externally on the same side. Perithecium normally single, short-stalked, subsigmoid, its apex rather broad, slightly bent upward, blunt, unmodified, sometimes slightly oblique. Perithecia 45–48 × 14–15 μ. Receptacle 38–44 × 12 μ. Secondary appendage, longest, 65 μ; primary 28–35 μ. Total length to tip of perithecium 75–80 μ.

On the elytra of a bluish black *Heterophyllus*. Hayti, No. 2760 (Mann Coll.).

This small and rather insignificant species is very closely related to *D. proximus*, which occurs on a similar host in Hayti, but differs in certain characters, which are referred to under that species, and seem to separate it with sufficient definiteness.

Dimeromyces proximus Thaxter. Plate IV, figs. 95–99.

L. c. **55**, 242.

Male individual hyaline, or very faintly tinged with brownish yellow; the cells very clearly defined. Receptacle erect, of four or five cells; the basal narrower and somewhat longer; the rest considerably flattened and oblique. Appendage erect, slight tapering, of usually four cells; the basal larger, and not differentiated from the receptacle; the subbasal very faintly brownish; the distal longer, hardly reaching the tip of the antheridia of which there are one to three, relatively rather slender; the stalk-cell short and well defined; the venter slightly inflated; the neck curved outward. Receptacle 28 μ. Antheridia 28 × 6 μ. Appendage 20–25 μ. Total length to tip of antheridium 58 μ.

Female individual faintly tinged with pale brownish yellow, or nearly hyaline, erect, rather compact. Receptacle of six, less often seven, cells, flattened and obliquely superposed above the somewhat longer basal cell. Primary appendage similar to that of the male, four- or five-celled: secondary appendage appressed, bent upward against the perithecium and arising from two

or three of the cells immediately below it, hardly reaching to its tip, rather stout and but slightly tapering, of six or seven cells. Perithecium usually single, erect, straight or nearly so, rather stout, subsessile; the tip tapering rather abruptly to the small bent apex, from which two auricle-like lips project somewhat sidewise: becoming faintly brownish with age. Perithecia 38–50 × 12–14 μ. Receptacle 30–38 μ. Primary appendage 28–38 μ; secondary 45–60 μ. Total length to tip of perithecium 75–100 μ.

On the elytra of *Heterophyllus* sp., No. 2759, Hayti; M. C. Z. (Mann Coll.).

This small species is very closely allied to *D. Heterophylli*, which occurs on another species of *Heterophyllus* without maculation, the host of the present form having an orange spot on the elytra. It was separated with some hesitation, but the differences seem distinct and constant. The most striking character which distinguishes the two is found in the form of the perithecium and the modification of its apex, *D. Heterophylli* lacking entirely the small auricular projections formed by two of the lips in *D. proximus*.

Dimeromyces appendiculatus Thaxter. Plate VI, figs. 161–164.

L. c. **55**, 249.

Male individual faintly tinged with yellowish. Receptacle broader than long above the large foot; of three cells, the basal greatly flattened, and extending outward and upward, beside the subbasal, above the insertion of the lower of the two antheridia; which arise from the subbasal and distal cells, the former projecting above the latter owing to its much longer stalk-cell; the venters relatively narrow; the necks stout and curved, or bent inward or sidewise, sometimes almost at right angles. Appendage long, five- or six-celled, and abruptly slender above the large basal cell. Receptacle 19 × 20 μ. Antheridia, upper, 35 μ, lower 45 μ. Appendages, longest seen, 45 μ. Total length to tip of lower antheridium, including foot, 60 μ.

Female individual pale yellowish. Receptacle as in the male, but of four cells, the lower becoming somewhat distorted or displaced; the basal also forming a narrow margin, which extends up to, and is united to, the end of the basal cell of the single secondary appendage; which arises from the subbasal cell, both primary and secondary similar, becoming slender above the latter, rather closely septate below; the subbasal cells darker. Perithecium relatively large, sessile, without stalk, broader at the base, tapering gradually upward, bent, curved or arcuate; the tip abruptly somewhat narrower; the apex subtended by a slight indentation, and bearing a small, tooth-like prominence on one side, and a long, slender, usually upcurved and distally clavate appendage on the other. Perithecia 115–150 × 14–17 μ, the appendage 40–50 × 7.5 μ at tip. Receptacle 15 × 22 μ, exclusive of large foot. Longest appendage 95 μ. Total length to tip of perithecium 135–170 μ.

On the antennae of *Leiochrodes medianus* and *Leiochrodes* sp., Nos. 2996–2998, Auki and Fulakora, Solomon Is. (Mann Coll.).

Although so aberrant in the form of its receptacle, and the possession of a well developed perithecial appendage, or trigger organ, this very distinct species is perhaps as nearly related to *D. luteus*, which occurs on the same host, as to any other; the appendages, with their rigidity and modified subbasal cells, being similar. The cell relations of the receptacle, which, in figure 162, is shown in optical section, are often confused by the irregular development of certain cells. The narrow upward extension of the basal cell, which is united to the secondary appendage and extends to its subbasal cell, gives the short broad receptacle a very characteristic appearance.

Dimeromyces sulcatus Thaxter. Plate V, figs. 123–125.

L. c. **55**, 248.

Male individual hyaline, slender, erect; the receptacle consisting of three very obliquely superposed cells, more than half of the basal in contact with the subbasal. Appendage erect, subcylindrical, rather stout, of five or six cells, longer than the receptacle; the basal cell undifferentiated, free, the subbasal somewhat narrower and denser. Antheridium single, sometimes two, suberect; the stalk relatively long and slender; the venter rather long and narrow; the long neck bent somewhat abruptly above its base, and curved inward, or sidewise, often at right angles. Receptacle 25 × 8 μ, without small pointed foot. Antheridia, to bend of neck, 34 × 5–6 μ. Appendage 38–45 × 4.5 μ.

Female individual almost perfectly hyaline, erect; the receptacle consisting of four cells, otherwise like that of the male; the primary appendage of four or five cells, erect, nearly uniform in width, the subbasal slightly narrower; secondary appendage arising from the subbasal cell, erect, straight, nearly uniform, of seven or eight cells, reaching slightly above the middle of the perithecium, which it subtends. Perithecium long and slender, straight or distally curved outward, broader at the point of curvature; the tip slightly inflated, and distinguished above and below by prominent constrictions; the apex nearly as long, deeply sulcate or bilobed, the margins convex. Perithecia 90–105 × 12–15 μ. Primary appendage 40–45 × 5 μ; secondary 65–75 × 5 μ. Receptacle 30–34 × 12 μ. Total length to tip of perithecium 120–148 μ.

On the elytra of *Leiochrodes* sp., Los Baños, Philippines, No. 3043.

The host, on which this well marked species occurred, was very kindly sent me by Dr. W. H. Weston. Although in fundamental characters it is similar to *D. luteus* and other forms which occur on species of *Leiochrodes*, it is very well distinguished by its slender habit and deeply sulcate apex. As in the other species, the two appendages form a socket, as it were, into which the perithecium is inserted. The latter shows no clear differentiation of a stalk.

Dimeromyces decumbens Thaxter. Plate V, figs. 116–117.

L. c. **55**, 247.

Male individual dull brown, straight, receptacle three-celled, the basal transversely maculate, except its oblique extremity. Appendage short, hardly reaching the end of the venter; the basal cell square, suffused; the subbasal similar, deeper or opaque; the terminal longer than both, suffused below and externally, its blunt hyaline apex protruding beyond the blackened margin of the ruptured sheath. Antheridium single, erect, touching the appendage; the stalk well developed; the neck clearly distinguished, about as long as the venter, slightly tapering, bent somewhat sidewise distally; the whole evenly pale brown. Receptacle 50–60 μ. Appendage 38 μ. Antheridia 80–18 μ. Total length 125 μ.

Female individual more or less uniformly dull brown. Receptacle of four cells, the basal maculate, like the male, the rest obliquely superposed, the subbasal producing the single very large secondary appendage, of six or seven cells; subsigmoid, the basal longer, curved, the rest successively shorter, separated by slight constrictions, and with somewhat convex margins; the distal again longer, distally slightly tapering, irregularly divided or disorganized. Primary appendage short, similar in structure and suffusion to that of the male. Perithecium very large, the somewhat paler stalk not distinguished from the rest, the lower half or more of the ascigerous part more deeply suffused; the tip well distinguished by prominences on both sides; the blunt somewhat asymmetrical apex slightly bent away from the secondary appendage; the whole projecting upward beside the appendage at an angle of 45° or more from the prostrate receptacle.

Perithecium 235–310 × 38–342 μ, the stalk 60–80 μ. Receptacle 70 × 34 μ. Primary appendage 45–60 × 12–14 μ: secondary 250–290 × 20–22 μ. Total length to tip of perithecium 365–380 μ.

At the base of the posterior legs of *Leiochrodes* sp., Auki, Solomon Is., No. 2950 (Mann Coll.), M. C. Z.

The male individual, as well as the receptacle and primary appendage of the female, appear to lie flat on the surface of the host, the secondary appendage and the perithecium diverging upward at a variable angle. It is a very large species, closely allied to *D. longicollis*, *D. rugosus* and the other species which occur on members of the genus *Leiochrodes*.

Dimeromyces longicollis Thaxter. Plate V, fig. 118.

L. c. **55**, 246.

Male individual rather uniformly tinged with yellowish brown. Receptacle of three cells, somewhat obliquely superposed; the basal longer; the subbasal flattened. Appendage erect, of four cells; the basal squarish; the subbasal slightly smaller, and deeply suffused with blackish brown, the portion above slightly broader, then tapering to a blunt apex. Antheridia one or two, relatively large and long; the stalk well developed, abruptly bent upward at its origin; the venter convex externally, and rather abruptly distinguished from the tapering base of the very elongate neck, which reaches considerably above the tip of the appendage. Receptacle 50 × 17 μ. Appendage 50–60 × 7 μ. Antheridia 85 × 14 μ, the necks 42 × 3 μ. Total length about 140 × 18 μ.

Female individual tinged with yellowish brown, the perithecium becoming rich dark brown. Receptacle consisting of four cells, the two middle ones flattened and very obliquely superposed. Primary appendage consisting of five or six cells. Secondary appendage from the subbasal cell, erect, distally tapering to a blunt apex, of about seven cells, somewhat longer than the primary, and stouter in the middle, but otherwise similar, the basal cell relatively large, oblique below. Perithecium long and slender, erect, slightly flexed inward distally, blackish brown, the stalk-portion pale and rather clearly distinguished; the tip hardly distinguished, but finally indicated by a deeper subtending suffusion; the short, hyaline, slightly oblique apex turned slightly outward and usually subtended on the inner side by the persistent base of the trichogyne. Perithecia 250 × 30 μ. Receptacle 64 × 22 μ. Primary appendage 64–84 × 12 μ: secondary 100–120 × 12 μ. Total length 275–310 μ.

On the elytra of *Leiochrodes medianus* Westw., Nos. 2951 and 2997, Auki, and No. 2998, Fulakora, Solomon Islands (Mann Coll.).

This species is allied to the other species on *Leiochrodes*, especially to *D. decumbens*, but differs clearly in the form of the perithecium, and the length and character of the appendages in the females; but especially in the greatly elongated neck of the antheridium in the male; a character which has suggested the specific name. In both sexes of one pair there is a slight maculation of the basal cell, similar to that seen in *D. decumbens*, but no other individuals show this character.

Dimeromyces rugosus Thaxter. Plate V, figs. 113–115.

L. c. **55**, 245.

Male individual hyaline, becoming more or less deeply tinged with brown. Receptacle of three cells, the basal longer, the subbasal somewhat flattened and oblique, separating a small cell externally. Appendage of three or four cells, stout and somewhat tapering; the basal cell

symmetrical, somewhat longer than broad, about as large as the distal cell of the receptacle. Antheridia one, or rarely two, abruptly erect; the stalk-cell well developed; the venter slightly inflated; the neck relatively short, and curved abruptly sidewise at its tip, or even recurved. Total length 75–92 × 17–21 μ. Antheridia 42–50 × 11–12.5 μ. Appendage 40 μ.

Female individual becoming rather dark brown, or partly opaque. Receptacle relatively small, of four cells; the two middle somewhat flattened and oblique; the basal longer. Primary appendage short and becoming rather irregular; the second and third cells broader than long, and usually darker. Secondary appendage single from the subbasal cell, subclavate, of usually five to nine cells; the basal cell long, curved upward, slender; the third and fourth darker, usually broader than long, hardly exceeding the middle of the perithecium, mostly longer than the primary. Perithecium relatively large, long, straight, subsymmetrical, becoming nearly opaque and transversely rugose above the hyaline base; the tip well distinguished, relatively short, tapering to the very short hyaline apex, which has the appearance of a shallow cup, but from some points of view may be blunt or irregularly oblique. Perithecia 125–200 × 26–30 μ. Receptacle 42–64 × 35–45 μ. Primary appendage 60–80 μ, secondary 100–160 × 16 μ. Total length to tip of perithecium 125–200 μ.

On the elytra of *Leiochrodes medianus* Westw., Nos. 2998 and 2951 (Type), Auki, Solomon Islands, M. C. Z. (Mann Coll.). On *Leiochrodes minutus* Pic., No. 1836; Sarawak, Borneo.

This species is distinguished by its finely rugose perithecial wall, the rugosity forming transverse lines, hardly visible in the mature perithecium which may be nearly opaque. The apex usually appears flat and hyaline, with symmetrical marginal prominences on either side, giving the effect of a shallow cup. This form is not, however, always apparent; the conformation apparently varying according to the angle at which the perithecium is viewed. There is considerable variation in the depth of the suffusion in different individuals. The rugosity is also variably distinct. Some individuals, like that represented in figure 114, approach *D. longicollis*, which is closely allied, and differs more especially in its very long-necked antheridium.

Dimeromyces luteus Thaxter. Plate V, figs. 119–122.

L. c. 55, 244.

Male individual relatively large, pale yellowish, slender: the receptacle consisting of three obliquely superposed cells, the basal long and slender, the others subequal, one or both producing antheridia. Appendage of three or four cells, the basal larger, rather clearly distinguished from the slightly brownish narrower cells above. Antheridia relatively long and slender, the stalk-cell well defined, bent inward; the upper one in more or less continuous contact with the appendage; the necks reaching nearly to the tip of the appendage, rather strongly curved inward. Receptacle 55–65 × 12 μ. Appendage 40–45 μ. Antheridia 46–50 × 9 μ. Total length 95–100 × 14 μ.

Female individual clear pale yellow, often becoming slightly suffused with brownish; straight and erect. Receptacle consisting of four cells: the basal somewhat elongate, the second and third oblique and flattened: producing normally a single perithecium from the third, and a secondary appendage from the second. Primary appendage shorter than the perithecium, and erect beside it or rarely slightly divergent; its basal cell much larger, long, and broader than the subbasal; which is clearly distinguished by its brown color: secondary appendage seldom as long as the perithecium, and lying close against it; its basal cell longer, the following six or more squarish, the subdistal ones broader, the lowest tinged with brown. Perithecium often becoming tinged with brown, straight, erect, rather stout, sessile, subsymmetrical, with more or less straight margins; the tip- and apex-regions abruptly distinguished; tapering to a rather broad bluntly rounded

termination. Perithecia 90–100 × 24–30 μ. Receptacle 60–65 × 20 μ. Longest appendages 75–100 μ. Total length to tip of perithecium 140–160 μ.

On the elytra of *Leiochrodes medianus* Westw., and of *Leiochrodes* sp., Nos. 2950, 2951, 2966 and 2997, Auki, Solomon Islands (Mann. Coll.).

In the group of nearly allied forms occurring on *Leiochrodes* this species is easily distinguished by its pale yellow color, and by the form of its sessile perithecium, lying parallel to the two appendages, which usually lie close against it, and between which it is inserted. The male is relatively unusually large, and differs from that of other allied species in its long slender habit, distally incurved necks and yellowish color. It occurs scattered over the elytra in pairs, often in company with *D. rugosus*. A small form has been examined from Sumatra in which the perithecia are marked by rather faint transverse granular lines.

10. ON ANTHICIDAE.

Dimeromyces Tomoderi Thaxter. Plate VIII, figs. 205–207.

L. c. **55**, 273.

Male individual hyaline, or very faintly tinged with brownish yellow. Receptacle very short and stout; the basal cell twice as broad as long, oblique, its posterior margin prominent and suffused with blackish brown; the subbasal somewhat narrower, externally convex, the base of the two-celled appendage half as broad, its cells subequal, hardly longer than broad, of uniform width, distally bluntly rounded. Antheridium from subbasal cell, relatively large and long; the stalk-cell well developed, twice as long as broad, nearly erect; the venter and neck well distinguished, straight, of nearly equal length. Receptacle 8 × 7 μ. Foot 8 × 10 μ. Appendage 8–9 × 3.5 μ. Antheridium 28 × 5 μ.

Female individual pale brownish yellow, becoming darker; the perithecium deeper brownish. Receptacle consisting of four somewhat obliquely superposed cells, somewhat flattened; the fourth distally prominent, and bearing the four-celled primary appendage subterminally, from the right side; the subbasal cell bearing the secondary appendage, which consists of four or five cells, hardly tapering, similar to the primary but slightly longer, reaching to about the middle of the perithecium, which arises from the third cell; stout, erect, its outer margin strongly convex, its inner more nearly straight; the stalk very short and abruptly narrow; the ascigerous portion very broad, and tapering distally to the stout moderately well distinguished, relatively large tip; the apex short, projecting to a blunt point, anteriorly, its distal margin flattish, oblique. Perithecia 50–55 × 20–22 μ. Appendages 18–25 × 25–4 μ. Receptacle 20 × 14 μ, exclusive of large foot. Total length to tip of perithecium 80–90 μ.

On the femur of anterior legs of *Tomoderus Kraatzi* Pic., No. 2590, Kamerun, West Africa.

This small species appears to be quite unlike any other described form and is the only species found as yet on the Anthicidae, which harbor so many other unisexual forms with simple antheridia. The apex of its perithecium appears differently from different points of view, the prolongation of the apex sometimes resembling a blunt tooth. The male is distinguished by its very large foot, short receptacle, and relatively long antheridium.

11. ON CHRYSOMELIDAE.

Dimeromyces Longitarsi Thaxter. Plate V, figs. 129–131.

L. c. **50**, 22.

Male individual hyaline, or faintly yellowish; receptacle consisting of three obliquely superposed cells; the subbasal smaller, the basal much larger. The appendage bent inward from the

distal cell, which is prominent below it externally; consisting of a much broader, distally somewhat rounded, basal cell, and a subulate distal cell of variable length. Antheridia normally two, somewhat divergent; the stalk small, and free only externally; the venter stout, and rather abruptly distinguished from the neck, which is stout, usually more or less strongly curved outward. Total length to tip of appendage 60–64 μ; to tip of distal antheridium 70 μ, including foot. Appendage 14–18 μ. Antheridium 22–28 × 8.5 μ.

Female individual tinged with pale yellowish, the perithecium more distinctly pale brownish yellow at maturity. Receptacle consisting of four obliquely superposed cells; the basal slightly larger, the second and third subequal; the upper terminated by the primary appendage, which is very similar to that of the male; a single, whip-like, distally slender and flexuous secondary appendage arises from the subbasal cell, its basal cell not distinguished from the adjacent cells of the receptacle; the whole exceeding the perithecium in length. Perithecium stout, or rather slender, strongly convex on the inner side, more nearly straight next the secondary appendage; the stalk-portion almost obsolete; the tip becoming rather clearly distinguished by depressions and slight elevations, rather abruptly paler, separated at maturity by a variably distinct constriction from the short apex; which is somewhat asymmetrical, rather abruptly inflated on either side, distally compressed and tapering abruptly to a blunt point. Perithecium 80–120 × 20–25 μ. Secondary appendage 85–100 μ; primary 25 μ.

On the elytra and prothorax of *Longitarsus testaceus* Mels., Fayetteville, Arkansas, No. 1801; of *L. subcinctus* Har., No. 2455, and of *Aphthona Deyrollei* Baly, No. 2454, Port of Spain, Trinidad, B. W. I.

In this species, as in several others, it is not altogether clear which cell should be regarded as the basal cell of the appendage, and which the distal cell of the receptacle. An examination of very young individuals leads me to conclude that the receptacle should be regarded as consisting of four cells, while the appendage is made up of a very small basal cell and a subulate distal portion which may represent a second cell, or merely the pointed termination of the original spore. I have been unable to satisfy myself that it possesses a definite wall, although in the male this seems to be the case. The distal cell of the receptacle, as shown in figs. 129 and 130a, is united to the stalk of the perithecium, which arises from the cell below it. Although individuals from Arkansas and from the West Indies differ in no essential respects, there is a certain amount of variation in both instances, certain specimens being more elongate than those figured. The constriction which subtends the apex of the perithecium also varies greatly, and is prominent only in fully matured individuals. The species is nearly related to *D. Homophoetae* and can hardly be separated from *D. Bordei* Maire to which reference is made below. It may be mentioned that in figure 131 the antheridia are so turned that the curvature of the neck is much less conspicuous than is ordinarily the case.

Dimeromyces Bordei Maire.

Publ. d. l'Université d'Alger. 3me Contr. a l'Étude d. Laboulbéniales de l'Afrique du Nord. Alger, 1920. 4, Plate I, figs. 1–5.

This species is said to occur on the elytra of *Thyamis parvula* Payk, and to be intermediate between the two preceding species. From *D. Longitarsi* the female is described as differing in having a three-celled primary appendage, and a larger perithecium, in which the terminal constriction is slight or absent, the stalk free on both sides. The male is said to differ in having a two-celled primary appendage, which is not pointed, and reaches nearly to the apex of the antheridium. These discrepancies may be in part accounted for by the fact that as above mentioned, the constriction of the perithecial tip is prominent only in well matured specimens, and

by a difference of opinion as to which cells should be regarded as belonging to the receptacle and which to the appendage; and also whether the pointed apex of the latter should be regarded as a definite cell, which in the male it actually seems to be. In a dozen or more males of *D. Longitarsi*, which have been examined, none have an appendage reaching beyond the base of the neck of the antheridium; and, as shown in figure 130a, the fourth cell of the receptacle in the female seems definitely united to the stalk of the perithecium. The two forms, however, seem too closely related for satisfactory separation as distinct species.

Dimeromyces Homophoetae Thaxter. Plate V, figs. 132–135.

L. c. **50**, 19.

Male individual pale brownish yellow; the receptacle of three or four cells, those above the slightly larger basal cell slightly flattened and obliquely superposed. Basal cell of the appendage usually unlike the adjoining cell of the receptacle, and separated by a constriction and thin dark septum from the one- to several-celled distal portion, which ends in a long sharp spine. Antheridia two to five, one to three often arising from the cells of the appendage on which they are frequently terminal and subtended by its spine; the stalk-cell well developed, rather slender; the venter broader distally, and rather abruptly distinguished from the stout, straight, slightly tapering, somewhat longer neck. Total length to tip of appendage 60 μ, of antheridium 80 μ, of proliferous antheridium 112 μ; normal antheridium, including stalk, about 35–40 × 6 μ.

Female individual rather variable in size. Receptacle reddish brown below, or only the basal cell, distally yellowish: consisting of three or usually four cells obliquely superposed, the darker basal cell extending upward beside the subbasal to the insertion of the lower secondary appendage; the third cell bearing the single perithecium, and the fourth a second appendage. Primary appendages two, consisting of two cells about equal in length, separated by a rather distinct constriction; the distal slightly inflated at the base and narrower apex, which terminates in a sharp spine. Secondary appendages rather slender, tapering, often slightly swollen above the base, shorter than, or not greatly exceeding, the perithecium. Perithecium subfusiform, or externally more convex, straight, or sometimes slightly curved; stalk very short, hyaline, the rest reddish or yellowish brown; the tip and apex paler, distinguished by slight indentations; the latter somewhat spreading, and subsymmetrically three-lobed when viewed sidewise, the middle lobe more prominent; when turned, more compressed and bluntly pointed. Spores 32 × 3.5 μ. Perithecium 100–190 × 20–35 μ. Total length to tip of primary appendage 70 μ; of perithecium 140–250 μ. Appendages, longest, 90–110 μ.

On *Homophoeta aequinoctialis* Linn., No. 1577, Guatemala, inferior prothorax; No. 2066, Grenada, B. W. I., on antennae, and No. 2475, Port of Spain, Trinidad, B. W. I.

The specimens from Guatemala, on hosts collected by Professor Kellerman, are somewhat larger than the West Indian forms, but are otherwise similar. The male is decidedly variable, owing to the production of adventitious antheridia, and is usually in not very good condition. The female is readily distinguished by the peculiar form of the pointed terminal cell of its short primary appendage. The species does not seem allied to *D. Forficulae*, as formerly suggested, but rather approaches *D. Hermaeophagae* and *D. Longitarsi*, as well as the exotic species which have been described from Chrysomelidae.

Dimeromyces Hermoeophagae Thaxter. Plate V, figs. 136–139.

L. c. **50**, 21.

Male individual nearly hyaline. Receptacle of two somewhat obliquely superposed cells, the basal but slightly larger; the foot subterminal. Primary appendage erect, the basal but

slightly shorter than the cell below it, separated by a black septum from the two nearly equal cells of the distal portion. Antheridium erect, long and slender, exceeding the tip of the appendage; the stalk-cell long and slender; the neck rather stout and but slightly curved outward. Total length to tip of appendage 35 μ; of antheridium 50 μ. Antheridium 30–34 μ. Appendage 17 μ.

Female individual nearly hyaline or faintly yellowish. Receptacle normally of four cells, the basal slightly larger, with subterminal foot; the second and fourth bearing single secondary appendages, the basal cells of which are separated from the more slender, several-celled, slightly tapering distal part by a black septum. Primary appendage slightly divergent, similar to that of the male. Perithecium erect or more often bent near the base at an angle to the receptacle, arising from the third cell, almost sessile, somewhat asymmetrical, the outer margin straight or slightly concave, the inner convex; the tip usually well distinguished, slightly swollen; the apex funnel-shaped, abruptly and subsymmetrically spreading. Perithecium 60–70 μ. Primary appendage 20–25 μ; secondary 60–70 μ. Total length to tip of perithecium 75–90 μ.

On *Hermocophaga insularis* Jac., No. 2066, Grenada, B. W. I. (Brues).

This species occurs on the antennae of the host to which the receptacle is appressed, while the perithecia are curved outward. It is a small form, evidently most nearly allied to the other members of the genus which, like *D. geminandrus*, occur on Chrysomelidae. It is at once distinguished by its spreading apex, the distal margin of which is flat, or hardly rounded.

Dimeromyces Hyperacanthae Thaxter. Plate VII, figs. 171–173.

L. c. 55, 256.

Male individual hyaline to pale brownish yellow, relatively small, with large foot. Receptacle of three cells, the second and third strongly convex externally, the former lying beside the distal half of the much larger basal cell, both bearing antheridia, as a rule: the latter slender, erect, somewhat flaccid, the neck slightly curved and relatively long. Appendage erect, hardly reaching the tip of the antheridium, the broader basal cell separated from the two-celled distal part by a broad black septum and slight constriction. Receptacle 30 × 12 μ, exclusive of foot, which is 16–18 μ. Appendage 42 μ. Antheridia 42 × 5.5 μ.

Female individual rather uniform translucent reddish brown with a yellowish tinge, of erect habit. Receptacle consisting of normally five cells, the basal larger, the rest slightly flattened, strongly convex externally, very obliquely superposed, and forming a divergent series from above it: the second, third and fifth bearing secondary appendages; their basal cells distinguished above by broad, black, somewhat constricted septa; the lower giving rise, usually, to two branches, similar to those above, rigid, erect or suberect, tapering but slightly, their often disorganized tips hardly reaching to the extremity of the perithecium. Primary appendage short, of usually three cells, the basal not distinguished from the receptacle, its outer margin strongly bulging, so as to throw the insertion of the blackened septum, at the base of the distal portion, inward. Perithecium somewhat darker, normally arising from the fourth cell; straight, erect, nearly sessile, relatively short and stout, rarely more slender; the outer margin less convex than the inner; the short tapering tip but slightly distinguished; the lip-cells compressed, elongated, and forming a terminal pseudo-appendage, which is bent strongly and abruptly inward. Perithecia 100–135 × 30–36 μ. Receptacle, excluding foot and basal cell of primary appendage, 50–85 × 25 μ. Appendages 100 × 6 μ, longest 150 μ. Total length to tip of perithecium 160–210 μ, the more slender form up to 335 μ, owing to the elongation of the perithecium.

Forming a dense group on the free upper surface of the tip of the abdomen of *Hyperacantha robusta* Ws., and *Hyperacantha* sp., Nos. 3070–3071, Metet, Kamerun, West Africa.

The more elongate form of this peculiar species, above referred to, was found protruding from beneath the tips of the elytra. The pseudo-appendage of this variety tends to be more erect, and the margins of the cells of the receptacle are but slightly convex; while the cells themselves are narrower. The elevations distinguishing the tip are also much more prominent. It is possible that this form may prove distinct, but its differences are probably due to its somewhat different position of growth. The species is evidently allied to the other forms parasitic on Chrysomelidae.

Dimeromyces geminandrus Thaxter. Plate VI, figs. 140–145.

L. c. **55**, 253.

Male individual hyaline to yellowish, or faintly brownish. Receptacle slender, erect, consisting of from two to six cells; the basal longer; the rest somewhat flattened, and obliquely superposed. Basal cell of primary appendage straight, erect, nearly isodiametric, about three times longer than broad, separated from the usually three-celled distal portion by a broad black septum. Antheridia two to a dozen or more, often adventitious, even from the basal cell of the primary appendage; which is usually inserted between two symmetrically placed antheridia, which arise distally, on either side, from the terminal cell of the receptacle, their necks curved outward in opposite directions; the rest arising often irregularly from the cells below, on one side, rarely associated with a secondary appendage, from the basal cell of which one or more adventitious antheridia may arise. Antheridia long and slender, the long stalk-cell abruptly erect, or but slightly divergent; the neck slightly curved outward. Receptacle, without foot, 40–80 × 8–12 μ. Distal part of primary appendage 40 × 4 μ, more or less, the basal cell 18–20 × 6 μ. Total length to tips of highest antheridia 80–159 μ.

Female individual very variable in size, and in the development of its appendages and perithecia. Receptacle rather short, consisting of from five to eight somewhat flattened, obliquely superposed cells, variably tinged with reddish brown; the subterminal giving rise to the usually single perithecium, below which two to four cells, as well as the terminal one, give rise to secondary appendages; the latter single and simple, or their basal cells proliferating to form two to four branches, separated by black constricted septa, usually slender and very elongate, flexuous and hyaline; basal cell of the primary appendage usually short, unmodified; producing one or more adventitious branches, similar to the secondary appendages, on the inner side. Perithecium normally single, rarely two or three; extremely variable in size and form, sometimes nearly sessile with a broad base, more often with a greatly elongated stalk; which is yellow, not distinguished from the reddish brown ascigerous region; the tip usually rather well distinguished by slight elevations, and tapering symmetrically to the clearly defined apex, which, in face view, is more or less broadly spreading, symmetrically rounded, with marginal indentations; the lateral view asymmetrical, compressed, blunt, usually with a slight subterminal enlargement. Perithecia 150–925 × 20–30 μ. Receptacle 70–125 × 20–40 μ. Longest appendage seen 715 × 5 μ.

Near the apex of the elytra of *Hyperacantha Kolbei* Ws., Type, No. 3072; *Hyp. robusta* Ws., No. 3070 and of *Diacantha Deussenii* Karsch., No. 3073, Kamerun, West Africa.

A reexamination of copious material of this form and of *D. Aulacophorae* has led me to feel doubtful whether the two are best kept distinct. The male is ordinarily recognized by the paired antheridia which terminate the receptacle symmetrically, enclosing the basal cell of the appendage, figures 143–144. The basal cell of the primary appendage, in the female, is not distinctive, as is usually the case in *Aulacophorae*. The perithecia may be extraordinarily developed, sometimes reaching a millimeter in length in the type material; while the form on *Diacantha Deussenii*, figure 142, which is not otherwise clearly separable, has nearly sessile perithecia,

tapering from a broad base. The branches of the appendages may also be very greatly elongated and slender. The type comprises six other closely related forms, namely, *D. auriculatus*, *D. helicoideus*, *D. Aulacophorae*, *D. rigidus*, *D. nigricaulis* and *D. Hyperacanthae*, all of which parasitize Chrysomelidae.

Dimeromyces rigidus Thaxter. Plate VI, figs. 155–157.

L. c. **55**, 249.

Male individual straight, erect, hyaline, becoming more or less deeply tinged with brown. Receptacle of from five to seven cells; the basal short, subtriangular, hardly larger than those above it; which are flattened and oblique, with slightly convex margins. Basal cell of the primary appendage rather abruptly narrower than the cell below it, somewhat longer than broad, distinguished by a black septum and constriction from the distal portion; which consists of two or three cells, and becomes dark brown. Antheridia one to three or four, associated with one to three erect, brown secondary appendages, very similar to the primary; the stalk-cell relatively long and slender; the venter rather short; the very long slender neck as long as both combined, or longer, distally bent outward; the whole erect, or somewhat divergent. Receptacle, exclusive of large foot, 30–40 × 10.5–14 μ. Primary appendage 30 μ. Secondary, larger, 50 × 5 μ, distinguished, above the basal cell, by a black septum. Antheridia 50 × 6.5 μ.

Female individual becoming more or less deeply suffused with dark brown. Receptacle straight, or but slightly curved, consisting of usually six cells; the basal short and subtriangular; the rest more or less flattened and oblique. Primary appendage similar to that of the male. Secondary appendages arising from all the cells of the receptacle above the subbasal, except the subterminal; their broadened basal cells producing from two to more often four, erect, stout, rigid, deep reddish brown branches, distinguished by broad, black, constricted basal septa, and more or less transversely arranged. Perithecium single, rarely two, relatively very large, bent abruptly erect from its insertion; the stalk stout and paler, nearly or quite half the total length, often not clearly distinguished from the sporiferous portion; which is darker, somewhat asymmetrical, abruptly distinguished by a well defined elevation on both margins from the rather slender tapering tip; the apex abruptly distinguished, distally compressed, its abruptly broader base forming a conspicuous prominence on the inner, and a lesser somewhat higher on the outer, margin; the termination much compressed, the lips small, the inner somewhat prominent: the whole appearing in face view subsymmetrical, ligulate or spathulate, distally rather broadly rounded. Perithecia 275–355 × 25–30 μ. Receptacle, without foot, 65–75 × 25 μ. Appendages 150 × 8 μ or longer. Total length to tip of perithecium 390–425 μ.

On the inferior surface of the abdomen of *Aulacophora* sp., No. 2948, Auki, Solomon Islands, M. C. Z. (Mann Coll.).

This large species seems well distinguished by its dark color, brown, rigid appendages, and the form of its perithecia and antheridia. The secondary appendages seem, in most cases, to be proliferous after breakage, and may be longer than the measurements indicated. They do not seem, however, greatly to exceed one third the length of the perithecium. The species is most nearly related to *D. Aulacophorae*, of which it may possibly prove to be a regional variety.

Dimeromyces Aulacophorae Thaxter. Plate VI, figs. 146–154.

L. c. **50**, 20 and **55**, 252.

Male individual hyaline to yellowish or variously tinged with brownish. Receptacle erect, of three to six cells, bearing a variable number of antheridia, one to four or five, and one or

more secondary appendages, above the basal cell. Antheridia rather slender, the stalk-cell well developed, about a third of the total length, and free; the neck usually somewhat shorter than the venter, and more or less strongly curved outward. Secondary appendages somewhat uniform, of four to six cells, the basal distinguished from the subbasal by a dark septum and constriction. Basal cell of the terminal appendage usually brown, and sometimes as long, or even longer, than the usually three-celled, rather uniform distal part, from which it is separated by a blackened septum and constriction. Receptacle 20–42 × 10 μ. Basal cell of appendage 16–34 × 6 μ; distal part 42 μ or less by 4 μ. Antheridium, including stalk, (12 μ), 30–34 × 5–6 μ.

Female individual pale yellowish, becoming variously suffused with brownish, or more or less evenly brownish throughout. Receptacle of from four to rarely six cells, flattened and obliquely superposed between the basal and the distal. Basal cell of the primary appendage usually brown, of nearly uniform width, variably elongated, straight, curved or even recurved; separated by a black septum and constriction from the distal portion, which may consist of from one to five or six cells. Secondary appendages very variable; when shorter, usually diverging characteristically, sometimes nearly at right angles; one to sometimes four; simple, or sometimes giving rise to two branches, separated from their basal cells by black septa and constrictions; usually, but not always, shorter than the perithecium. Perithecia usually single, arising from the subterminal cell, rarely two or even three; very variable, straight, curved, or falcate; broadly fusiform, or tapering above the middle to a somewhat attenuated termination; usually suffused with reddish brown below the tip; which is usually hyaline, and may be rather clearly distinguished; the apex small, somewhat spreading, trilobed, or asymmetrically and bluntly pointed according to the point of view. Perithecia 100 × 12–175–250 × 24–28 μ. Receptacle 40–65 × 16–20 μ. Total length to tip of perithecium 150–240–315 μ. Basal cell of primary appendage 16 × 10–38 × 8 μ.

On the elytra and sometimes other parts of various chrysomelid beetles, No. 2510, Type, on *Aulacophora postica*, Perak, Straits Settlements: No. 3052, genus undetermined, Mindanao, P. I. From the Solomon Is.: No. 2947, on *Aul. similis* Oliv., Tulagi; No. 2989, on genus indet., Wai Ai.; No. 2991, on *Platyxantha* sp., Pamna; No. 2993, genus undetermined, Rendova: No. 2994, on *Monolepta* sp., Rere: No. 2995, on *Monolepta* sp., Rere. From the Fiji Islands: No. 2988, on *Aul. nigoensis* Jac., Suva: No. 2990, on *Aulacophora* sp., Vanna Ava: No. 2992, on genus indet., Nausori: No. 3111, on *Hyperacantha sexaspilata* Fairm., Madagascar. From Kamerun, West Africa: No. 3070, on *Hyperacantha robusta* Ws. and No. 3071 on genus indet.

Since the type material of this species was first found on a specimen of *Aulacophora postica* in the M. C. Z. collection, a large additional representation has been obtained, as above indicated, which shows that the form is a very variable one, and makes its specific limitations very difficult to determine. Forms like that represented in figure 148 may be regarded as typical of the species; but variations occur, like that represented in figure 147 x, showing a reduction in the appendages, and a modification of the form of the perithecium which may be specific: while others, as in figures 148 and 142, tend to produce more elongate appendages, which approach those of *D. geminandrus*. The latter may not prove really distinct, but appears to differ in the more complicated and greatly elongated slender appendages, sometimes considerably longer than is represented in figure 141, and the primary appendage apparently always lacks the peculiar basal cell which is usually, though not invariably, characteristic of the present species. This modification is often more striking than it is shown in figures 146–147, since it is frequently relatively more slender, and often distally curved outward. The male does not appear to show bilateral pairing of antheridia from the basal cell of the primary appendage, and usually produces one or more secondary appendages, a rare condition in male individuals of the genus. Such ap-

pendages are rarely absent in this species, as in figure 154, but this absence, which seems invariable in *D. geminandrus*, is here exceptional.

The type is one about which several closely allied forms, all parasites of Chrysomelidae in the Eastern Hemisphere, are grouped: among which, in addition to *D. geminandrus*, are included *D. rigidus*, *D. nigricaulis*, *D. helicoideus*, *D. auriculatus* and *D. Hyperacanthae*.

Dimeromyces auriculatus Thaxter. Plate VII, figs. 168–170.

L. c. **55**, 254.

Male individual nearly hyaline. Receptacle erect, consisting of three cells, the two upper bearing superposed antheridia. Appendage consisting of a large basal cell and a slender, two-celled termination, subtended by a cup-shaped black septum and constriction. Antheridia slender, curved outward, with long stalk-cells; the necks slightly longer than the venter, and with purplish brown bases. Receptacle, above foot, 20 × 8 μ. Basal cell of appendage 8.5 × 4.5 μ. Antheridia 38 × 6 μ.

Female individual rather short and stout. Receptacle tinged with purplish brown, erect, subtriangular; consisting of five cells; the three middle ones similar, flattened, oblique and somewhat curved; the subterminal bearing the single perithecium; the second, third and fifth, secondary appendages; the latter rarely double, seldom exceeding the middle of the perithecium, more slender and rather closely septate above the basal cell, above which they are distinguished by broad black septa and constrictions; that from the terminal cell strongly curved outward: basal cell of the primary appendage small, bell shaped, separated from the short, slightly tapering, three-celled terminal portion by a black septum and constriction. Perithecia stout, erect, straight, slightly asymmetrical, subfusiform; the inner margin slightly straighter; yellow, with a brownish tinge, pale at base and tip; the stalk and tip not clearly distinguished; the latter tapering rapidly to the abruptly distinguished apex, which is inflated, its distal margin dome-shaped, and subtended on either side by a prominent auricle, broadly rounded distally, and narrower at the base. Perithecia 135–170 × 29–34 μ. Receptacle 42–55 × 22–25 μ. Longer appendages 85 × 8 μ. Total length to tip of perithecium 190–230 μ.

Growing in a rather compact group on the mid-distal surface of the right elytron of *Diacantha Deussenii* Karsch, No. 3073, Kamerun, West Africa.

Seven pairs of this form have been examined, all from the same individual, among which but slight variation is observable. The primary appendages are broken in all but one, in which the more slender short terminal portion has but three cells. The form and color of the perithecium is very characteristic, and the auriculate apex, which may be nearly symmetrical, is unlike that of allied forms on similar hosts. It is most nearly related to forms of *D. Aulacophorae* and *D. geminandrus*, but seems hardly a variety of either.

Dimeromyces helicoideus Thaxter. Plate VI, figs. 158–160.

L. c. **55**, 255.

Male individual erect, straighter, or but slightly curved. Receptacle hyaline, becoming slightly yellowish, its two cells of uniform diameter, the basal cell of the primary appendage narrower distally, separated from the free, two- or three-celled portion by a black constricted septum. Antheridia erect, appressed or but slightly divergent, normally solitary, pale purplish brown, except the hyaline abruptly outcurved distal half of the neck; stalk well developed. Receptacle, exclusive of foot, 34 × 8 μ. Appendage, above black septum, 25 × 5 μ. Antheridia 38 × 6 μ.

Female individual abruptly helicoid. Receptacle hyaline, becoming suffused with brown, except at the base; consisting of normally five cells, the three middle ones somewhat flattened and oblique, the fourth producing the normally single perithecium; the second, third and fifth secondary appendages normally single, the lowest rarely double. Primary appendage shorter, but similar to the secondary; which are long, though mostly broken, rather slender, slightly tapering, rather closely septate below, distinguished above the basal cell by a black septum. Perithecium strongly curved, or recurved so that the tip may touch the foot; the stalk usually well developed, but not distinguished, pale yellowish, merging into the rich dark purplish brown of the ascigerous portion; tip usually not distinguished; the apex subhyaline, short, blunt, unmodified. Perithecia 85–100 × 18 μ. Receptacle 42 × 12.5 μ. Appendages 50–170 μ.

Near the margin of the right elytron of *Crepidodera* sp. near *C. zambiensis* Jac., Nos. 3061, 3074, Metet, Kamerun, West Africa.

Although this species is nearly allied to *D. Aulacophorae*, and the related forms on Chrysomelidae, it seems well defined, and is clearly recognizable, even *in situ*, from its habit and position of growth. It is not to be confused with subhelicoid individuals of the last mentioned species, figure 148.

Dimeromyces nigricaulis Thaxter. Plate VII, figs. 165–167.

L. c. **55**, 251.

Male individual relatively small, subhyaline; receptacle of two cells, the basal about twice as large as the subbasal, which is somewhat obliquely separated, the margins slightly convex in both: basal cell of the appendage somewhat smaller, erect, separated by a thick, black cup-shaped septum from the short, straight, two-celled distal portion. Antheridium erect, curved outward distally; the stalk-cell well developed, constricted, and deeply suffused with blackish brown below the venter; the neck about as long as the venter and curved outward: a second antheridium sometimes developed from the basal cell of the appendage. Receptacle, including basal cell of appendage, without foot, 25 × 4.5 μ. Antheridia 25 × 7.5 μ. Appendage, above black septum, 12 × 4 μ.

Female individual uniform pale dirty yellowish brown, the receptacle somewhat darker; consisting of usually six cells, subequal, except the larger basal; the four middle somewhat flattened and obliquely superposed. Basal cell of the primary appendage somewhat longer than broad, distally narrower, the rest of the appendage short, uniform, unicellular, distinguished by a thick black septum and constriction; a secondary basal cell normally separated from the primary on the inner side, and similarly distinguished from a several-celled branch by a black septum: all the other cells of the receptacle, except the first and fourth, giving rise to the basal cells of secondary appendages, which usually bear two rather short, stout, few-celled branches, separated by thick black septa, transversely and somewhat irregularly paired. Perithecium arising normally from the fifth cell; relatively large, slightly and rather evenly arcuate throughout, abruptly bent outward at the base, even at right angles, or sometimes more nearly erect; narrower about the insertion and tip, but otherwise often nearly isodiametric; the tip slightly bent outward, well distinguished, paler, tapering asymmetrically to the short apex, which is distinguished only by the rather prominently rounded inner lip-cell. Perithecia 200–235 × 20–22 μ. Receptacle 70–85 × 22 μ. Appendages 40–60 × 8–8.5 μ. Total length to tip of perithecium 300 μ, more or less.

On the elytra of *Diacantha flavescens* Ws., No. 3069, Kamerun, West Africa.

Four males and about a dozen females of this species have been examined. More copious material would no doubt show greater variation than is above indicated. The species seems well

distinguished from *D. Aulacophorae* and its allies, to which it is nearly related, by the very characteristic blackish brown constriction which separates the stalk from the venter of the antheridium, as shown in figures 166–167.

SPECIES PARASITIC ON DIPTERA.

Dimeromyces rhizophorus Thaxter.

L. c. **36**, 412. Monograph, Part 2, 243. Plate XXVIII, figs. 6-8.

This form, which is parasitic on a small fly from New Guinea, was the first species known to have a penetrating rhizoid. This rhizoid, unlike that of *D. oscinosomalis*, is furcate, and the other characters of the two species clearly separate them. It has not been again found.

Dimeromyces coarctatus Thaxter.

L. c. **36**, 410. Monograph, Part 2, 244. Plate XXXVII, figs. 1–5 and 17.

Although destitute of any penetrating rhizoid, this species is very nearly allied to the preceding and to *D. oscinosomalis*. It has not been again seen since its original description. The host is a small fly from New Guinea.

Dimeromyces crispatus Thaxter.

L. c. **36**, 413. Monograph, Part 2, 245. Plate XXIX, figs. 14-15.

This remarkable form, which occurred rarely on the same host with *D. coarctatus*, is one of the rare instances in which what appear to be secondary axes bearing perithecia arise from the primary receptacle.* It is one of the most clearly defined species of the genus. No further material has been examined since its original description.

Dimeromyces oscinosomalis Thaxter. Plate IX, figs. 242–247.

L. c. **53**, 701.

Male individual hyaline and thin-walled; of two cells, the basal often swollen below, with a minute lateral foot, longer than the subtriangular or slightly irregular subbasal cell, which bears the antheridium, and is about as large as the basal cell of the three-celled appendage, the subbasal cell of which is twice as long as broad, brown, thicker-walled, slightly constricted at the thin dark septa; the distal cell rather long, thin-walled, and tapering. Antheridia erect, or slightly divergent; a second often arising, above the first, from the basal cell of the appendage; the neck rather stout, straight, or slightly bent. A secondary appendage sometimes arising from the subbasal cell of the receptacle, straight, stiff, divergent, of four or five short cells. Primary appendage, above dark septum, 20 × 2.5–3 μ. Antheridia 18 × 5 μ. Receptacle 25 μ.

Female individual subsigmoid in general habit, when well developed. Axis of the receptacle of usually four or five cells, the basal broad and hardly longer, with a minute lateral foot beside a stout, short, simple, tapering penetrating rhizoid, which is sometimes abruptly vesicular beneath the host's integument: the two distal cells smaller, rounded and more prominent; the rest somewhat flattened and oblique. Basal cell of primary appendage small and rounded; the subbasal much smaller, suboval, brown, and distinguished by a dark septum and constriction; the rest of the appendage short, tapering, of one or two cells. Secondary appendages usually three, of about six cells, curved, usually inward, and often diverging from the perithecium, which they exceed considerably in length; the distal cell enlarged and curved inward, often uncinulate, becoming irregularly

split into an upper and lower more or less spoon-shaped halves, or variously and irregularly broken and lacerate; the whole variably suffused with dark brown, distally curved or recurved; the basal cell smaller, and separated by a dark septum from the long, sometimes slightly inflated basal cell. Perithecium usually single, arising from the fourth cell, rather stout, slightly curved inward; the stalk obsolete; the outer margin strongly convex; the relatively large tip rather clearly indicated; the apex about as broad as long, clearly distinguished above a slight constriction; the lip-cells projecting variously to form a corresponding number of unequal, asymmetrical protrusions, which appear differently from different points of view. Perithecia 50–65 × 16–20 μ. Receptacle, exclusive of rhizoid, 35–50 × 12–16 μ. Appendages, primary, 18 μ; secondary, longest, 125 × 8 μ. Total length to tip of perithecium 75–95 μ.

On the inferior surface of the abdomen of *Oscinosoma inaequalis* T. Beck., No. 2139, Sarawak, Borneo.

This species is nearly related to *D. rhizophorus*, which is the only other species known to develop an entering rhizoid; but is more nearly related to *D. pedalis* on the same host, which may prove merely a variation dependent on its position of growth. It is also allied to *D. kamerunensis*. The male seems variable and its characters are determined with difficulty; since it seems very difficult to isolate single individuals. The only one thus isolated, figure 247, is somewhat abnormal in producing a secondary appendage from the subbasal cell, and a second antheridium from the basal cell of the appendage, the distal part of which is broken. As a rule it appears to be of the normal type, with one antheridium and a tapering appendage.

Dimeromyces pedalis Thaxter. Plate IX, figs. 248–450.

L. c. **53**, 699.

Male individual hyaline, receptacle of two cells, the basal much larger, with well developed normal foot; subbasal cell long and narrower, somewhat shorter. Basal cell of the appendage similar, bent upward at base, the subbasal cell twice as long as broad, separated by a thin black septum, faintly brownish below; the rest of the appendage rather long and tapering. Antheridium erect, the venter and neck about equal, the latter abruptly distinguished externally. Total length to tip of antheridium 28 × 8 μ. Antheridium 18 × 5 μ. Appendage 24 × 3 μ.

Female individual more or less tinged with brownish yellow, especially the appendages. The receptacle consisting of seven or eight cells, somewhat broader in the middle, the basal cell nearly twice as long as broad with normally developed foot, the cells just above small and flattened, slightly oblique; the basal cell of the primary appendage undifferentiated, narrower distally; the subbasal somewhat rounded, with thin dark septum; the distal part short and tapering. Secondary appendages three, or often four, separated from the narrow basal cell by a dark septum and suffusion, distally broader; the distal cell curved, inflated, becoming split in two or lacerate: suberect, of five or six cells, shorter than the perithecia: which are single, somewhat divergent, nearly straight and subsymmetrical; the short stalk rather abruptly bent, arising usually from the fifth cell of the receptacle; the tip hardly distinguished, the apex clearly so, slightly spreading, usually appearing subsymmetrically three-lobed, the middle lobe higher; or more irregular according to the point of view. Spores 18 × 2.5 μ. Perithecia 42–52 × 14 μ. Receptacle 35–40 × 8 μ. Appendages, primary, 30 μ; secondary, 40–50 μ.

On the legs of *Oscinosoma inaequalis* T. Beck., No. 2139, Sarawak, Borneo.

This form is too closely allied to *D. oscinosomalis*, of which it may prove a mere variation due to its position of growth. The female differs in having perithecia, with more or less symmetrically three-lobed tips, which are longer than the appendages; and in having a receptacle with a normally blackened foot which replaces the rhizoid, and consisting of more numerous

cells. Fifteen females and several males have been examined, but more abundant material may make its identity with *D. oscinosomalis* clear.

DIMEROMYCES KAMERUNENSIS Thaxter. Plate IX, figs. 239–241.

L. c. **53**, 700.

Male individual relatively very small, faintly tinged with brown. Receptacle of two cells, the subbasal narrower, but nearly as long as the basal. Basal cell of the hyaline appendage small, slightly prominent externally, separated from the relatively long and slender several-celled distal portion by a thick black septum. Antheridium normally single, its venter brownish and rather strongly convex externally; the neck rather stout, hyaline, and slightly divergent above the base. Length to tip of antheridium 30 × 8 μ. Appendage 20–40 μ.

Female individual: axis tinged with brown above; the basal and subbasal cells subhyaline, the former several times as long as broad; the remaining eight to ten somewhat flattened, especially below, with rounded outlines. Primary appendage small, the basal cell rounded, slightly flattened; separated from the short, tapering distal portion by a black septum and constriction. Secondary appendages usually five to seven, slightly divergent, or suberect, slightly curved backward distally; alternating right and left, relatively stout, more or less deeply suffused with brown; mostly slightly longer than the perithecia; one or two of the upper shorter, consisting of usually seven cells, the basal tapering and deeply suffused distally about the septum, above which they are broader; the cells successively somewhat shorter, the subterminal very small and rounded into the cavity of the distal, which is at first rather abruptly inflated below, and tapers to a blunt extremity; but later is disorganized, the spreading or revolute remains of its wall persistent and adherent around the minute subterminal cell. Perithecia one or two, uniformly pale dirty brownish yellow, the apex hyaline; relatively small, slightly shorter than the appendages; the lower half slightly inflated, tapering thence rather evenly to the broad apex, the compressed inner lip-edges forming a short, slightly oblique, subconical projection, subtended by three well marked papillae. Perithecia 88–105 × 14–21 μ. Appendages, longest, 105 × 12 μ. Primary appendage about 25 × 3 μ.

On the head and legs of a pale yellow oscinid fly with slightly smoky wings, No. 2367, Kamerun, West Africa.

This species is most nearly related to *D. coarctatus* and *D. oscinosomalis*, but differs widely in the structure and position of its perithecia and appendages. The large dark appendages tend to conceal the relatively small perithecia, or render them inconspicuous. The relatively small male individual, in one instance, appears to develop two antheridia; but it is not possible to determine whether the receptacle in this case consists of three, rather than two, cells, or whether the second antheridium arises from the basal cell of the appendage.

SPECIES PARASITIC ON ORTHOPTERA.

DIMEROMYCES THAXTERI Maire. Plate VIII, figs. 217–220.

Bull. d. l. Soc. d'Hist. Nat. d. l'Afrique d. Nord **7**, 100 (1916).
D. falcatus Thaxter *nec* Paoli, l. c. **51**, 4 (1915).

Male individual pale yellowish, or nearly hyaline; its axis curved or subsigmoid, tapering distally, and consisting of from five or six to a dozen cells; the distal longer and more slender; the basal cell narrower above the very large foot, its distal half usually, but not invariably, deep blackish; the three or more cells immediately above, subequal, or successively smaller, and bearing

antheridia: the cells of the axis sometimes more numerous, and bearing short branches on which one to several antheridia may be borne. Antheridia slender, the stalk-cell sometimes even longer than the venter, which contains but two antheridial cells from which no basal cells are separated; neck about as long as the venter, slender, straight or curved. Total length of axis 80–94 μ, including foot (25 μ). Antheridia, with stalk, 40 × 5 μ.

Female individual similar to the male, becoming brown, falcate or subsigmoid, the axis of about twenty-five cells, the five to seven lower corresponding to the receptacle proper, thicker-walled and shorter, except the basal and subbasal, which are separated by a broad, deep, blackish, often oblique suffusion which involves their adjacent ends and the intervening septum; the subbasal about as long as broad, and bearing anteriorly the seven- or eight-celled secondary appendage, which bends abruptly upward, at its much broader base, beside the perithecia and receptacle. Perithecia two, or usually three, erect, arising from successive cells in a slightly oblique series; the very short or almost obsolete stalk bent abruptly upward; the main body asymmetrical, slightly broader, distally, the inner margin convex, the outer slightly concave, or straight, tapering rather abruptly to the tip, which is subtended by a slight elevation on the inner side, bent slightly inward, the compressed narrow blunt apex concave externally, and forming a pseudo-appendage. Perithecia 85–100 × 20–24 μ. Spores, female, 18 × 3 μ. Total length of axis 350–390 μ. Receptacle 80 × 20 μ, face view × 30 μ. Secondary appendage 45–70 μ.

On the antennae of *Gryllus mitratus* Burm., No. 2378, (Type), Samarang, Java: *Gryllus* sp., No. 3029, Wainoni Bay, Solomon Islands: on a genus of Gryllidae, No. 3047, Zamboanga District, Mindanao, Philippine Is.

Owing to a regrettable piece of carelessness, the name "*falcatus*," already employed by Paoli for a species of this genus, was used in the original description. This error was later noted by Maire, who proposed the present name, as above cited. The species is a very striking one, apparently of wide distribution in the East, and is remarkable for its long falcate axis, in which the receptacle seems only to be distinguished by its shorter cells, with small rounded lumina and very thick walls. The secondary appendage is often completely hidden, and can only be seen from one side. Male individuals sometimes occur, like that represented in figure 220, in which some or all the antheridia are replaced by short branches bearing the latter, and may in some cases be even more highly developed than in the specimen figured. The antheridia, like those of *D. Petchi*, possess but two antheridial cells, from neither of which does a basal cell appear to be separated. The near relationships of this form to other known species is not apparent.

Dimeromyces i-flagellatus Thaxter. Plate IX, figs. 236–238.

L. c. **55**, 281.

Male individual hyaline, the receptacle straight, of two cells; the basal relatively very large and long, of nearly equal diameter throughout; the subbasal angular or subtriangular, obliquely separated from the larger basal cell of the appendage, which is more or less prominent externally, the slender, usually shriveled distal portion of (?) two cells. Antheridium divergent, usually single, a second sometimes developed from the basal cell of the appendage; rather long and slender; the stalk-cell well defined; the neck long, slightly curved outward, and tapering gradually from a relatively large base to the slender extremity. Axis, including basal cell of appendage, 25–30 × 5.5 μ. Antheridia 25 × 4 μ. Basal cell 20 × 5.5 μ.

Female individual erect, straight, nearly hyaline or faintly yellowish. Receptacle consisting of usually five cells, the basal relatively very large and relatively long, sometimes broader below; the distal cell hardly differing from the basal cell of the appendage, which may be somewhat

longer, even twice as long as broad, external margin more nearly straight, its distal margin more or less distinctly oblique, prominent on the inner side below the small, squarish, suffused, much narrower subbasal cell, which is followed by a variable number of slightly broader and more rounded cells; the series of four or five terminating in a longer cell, which tends to become disorganized: the whole more or less divergent, or slightly curved outward above the basal cell. Perithecium erect, usually quite sessile, rarely with a short stalk-portion, faintly yellowish distally; the outer margin converging from the middle, or somewhat above it when a stalk is present, toward the base and apex, forming an elevation which is almost an angle; the inner margin straighter, converging at the tip; which is somewhat asymmetrical, short, hardly distinguished; the apex slightly broadened, through the enlargement of the outer lip-cell, which is somewhat spoon-shaped, and lies partly over the inner. Spores, female, 28 × 2.5 μ. Perithecia 50–60 × 13 μ. Appendage 75–90 μ. Total length to tip of perithecium 95–105 μ. Basal cell, largest 42 × 10 μ.

On the head and prothorax of *Spongovostox alter* Burr., Porto Vehlo, Amazon, M. C. Z., No. 2242 (Mann Coll.).

This species is quite unlike any of the other forms known to occur on earwigs, and is peculiar from the absence of any secondary appendage in the female, and its almost invariably sessile perithecium. The divergence of the appendage from the usually broad and oblique distal margin of its basal cell, and the abruptly very much narrower and squarish suffused subbasal cell, give it a characteristic appearance. The appendage of the male seems to be evanescent above the basal cell, and has only been seen in a shriveled condition.

Dimeromyces Australasiae Thaxter. Plate X, figs. 262–264.

L. c. **55**, 275.

Male individual hyaline, becoming faintly yellowish; straight, erect, rather slender: the receptacle consisting of three cells; the basal somewhat longer than the other two combined. Basal cell of the appendage hardly differentiated, bearing distally one, sometimes two, branches, two- to three-celled, short, somewhat tapering, and swollen above thick, black, subtending septa. Stalk-cell of the antheridium short, clearly defined; the venter relatively short, stout, inflated, much shorter than the necks, which are strongly bent outward, and characteristically indented on the inner side above the base. Axis, including basal cell of appendage, 38–44 × 9 μ. Antheridia 24–28 × 7 μ. Total length to tips of appendages, including foot, 60–75 μ.

Female individual faintly tinged with brownish. Receptacle consisting of four obliquely superposed cells, the basal as long as the rest combined; more or less strongly curved above the foot, convex on the posterior side: the subbasal cell bearing the lower secondary appendage, which is unlike the rest, its basal cell strongly convex externally, distally compressed, separated by a black constricted septum from the three remaining cells, which are of about equal length, the margins of the two lower nearly straight externally, and strongly convex near the base on the inner side; the distal cell slender, slightly tapering. Perithecium arising from the third cell; the stalk usually straight, erect, hyaline, sometimes longer than the ascigerous portion into which it passes gradually; the latter subfusiform, slightly asymmetrical; the tip sometimes clearly distinguished by an external indentation; the apex well defined, with a longer bluntly pointed outer lip, and a smaller shorter rounded inner lip. A secondary appendage arises from the terminal cell of the receptacle, the large basal cell of which gives rise to an oblique series of from two to five black septa, bearing rather short, simple, three- to four-celled branches; the whole overlapping the basal cell of the primary appendage, which is entirely similar in all respects. Perithecia, body 50–75 × 20 μ, stalk-portion 30–100 × 9–12 μ. Spores about 30 × 3.5 μ.

Lower secondary appendage, including basal cell, 38 × 42 μ. Branches of primary appendage 22–38 × 3.5 μ.

On the inferior surface of the abdomen and forceps of *Chelisoches morio* (Fabr.), Nos. 2949 and 3012, Auki; No. 3026, Florida, Solomon Is.; Nos. 3014, 3013 and 3027 from Nausori, Viti Leon and Nadarivata, Fiji Is., Mann Coll., M. C. Z.

This species, which belongs to the group of which *D. Forficulae* is the type, is very clearly distinguished from this species, as well as from *D. Anisolabis* and *D. Prorei*, which are its nearest allies, by the peculiarities of the lower secondary appendage in the female, and the geniculate neck of the antheridium in the male, as well as by other characteristics. The host is a large black forficulid on which it seems to occur not uncommonly.

Dimeromyces Anisolabis Thaxter. Plate X, figs. 268–273.

L. c. **48**, 156, 1912. L. c. **55**, 274. Spegazzini Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires **29**, 514, fig. 54.

Male individual hyaline, straight. Receptacle of three obliquely superposed cells; the basal larger, subtriangular; the others subequal. Antheridia arising from the distal cell, sometimes also from the subbasal, rather short and stout; the stout rather abruptly distinguished slightly tapering neck half of the total length, curved rather strongly outward distally. Basal cell of the appendage undifferentiated or rounded, separated by a black septum and constriction from the usually more slender, straight, erect, often uniform, three- to four-celled distal portion, which rarely exceeds the tip of the antheridium. Antheridia 31–38–42 × 7–10–12.5 μ. Appendage above septum 18–30–50 μ. Total length to tip of appendage 58–70–92 μ.

Female individual hyaline, or becoming somewhat suffused with yellow or brownish yellow. Receptacle short, compact, subtriangular, of four very obliquely superposed cells; the distal (lateral) margin often nearly horizontal. A larger secondary appendage arising from the subbasal cell, its nearly hyaline basal cell swollen, or inwardly prominent beside the base of its long, narrow, deeply blackened, distally broader and obliquely hyaline or translucent subbasal cell: the rest of the appendage hyaline, or suffused below; of four to seven cells; the lower broader, and more often brownish. The subdistal cell of the receptacle bearing a perithecium; the distal producing the primary appendage terminally, and one, or sometimes two, secondary appendages from the inner side, one of which may very rarely be replaced by a second perithecium, and which are similar in general to the lower appendage; but shorter, and distinguished above the basal cell merely by a blackish horizontal septum. Primary appendage shorter than the secondary, of five to seven cells, the distal longer, the rest hardly longer than broad; the basal hyaline, small and roundish, or larger and undifferentiated, distinguished above by a black septum and constriction, and rarely bearing on its inner side a branch similar to, but shorter than, the adjacent secondary appendage. Perithecia variably elongated and slender, becoming somewhat broader distally; the tip asymmetrical, more clearly distinguished on the inner side; the apex short and often slightly inflated. Perithecium 75–270 × 14–21 μ. Receptacle, above foot, 25–30–55 × 20–42 μ. Lower appendage 60–150 × 12–13 μ. Primary appendage 40–64 μ. Total length to tip of perithecium 100–230–350 μ.

On the inferior surface, near the tip, of the abdomen of *Anisolabis annulipes* Luc. (Type), No. 1682; of ? *Anisolabis* sp., No. 2924, Grand Etang, Grenada, B. W. I., and Arima, Trinidad, No. 2887. On *Euborellia janeirensis* (Dohrn) No. 2257, Independenzia, Amazon and No. 2263, Ceara Mirim, Amazon (Mann). On earwigs allied to *Anisolabis* from Fiji (Mann), Nos. 1016, Larema, No. 3017, Turuca: No. 3015, Wai Ai, Solomon Is. (Mann): No. 3145, Soochow, China (Gist Gee).

This widely distributed and common species is very closely allied to *D. Forficulae*, from which it may be most readily distinguished by the somewhat stouter receptacle, and the peculiar differentiation of the subbasal cell of its lower secondary appendage in the female: and in the male, by the presence of only one dark septum in the appendage. It is very variable in size, the larger dimensions above given having been taken from the specimens obtained at the Grand Etang, where it was common, some individuals bearing greatly elongated perithecia. The other variations which are found are associated, for the most part, with the appendages; the primary rarely giving rise to a branch from its basal cell on the inner side, as in figures 271–272. The single secondary appendage, which is normally borne by the distal cell of the receptacle, may be replaced by two, and may even be associated with a second perithecium, while in some instances, figure 268, this cell may give rise to neither. The peculiar lower secondary appendage may, as in figure 272, produce from its basal cell a branch which is similar to the upper appendages, and still another unusual variation is figured by Spegazzini (l. c.), in which the abnormal receptacle is five-celled, the second and third cells each bearing similar appendages. The asymmetrical tip of the perithecium also varies considerably, being sometimes clearly defined by an elevation on the inner side, or often hardly distinguished. It is seldom as narrow as in *D. Forficulae*, and in this species the lower appendage does not show the peculiar modification of its subbasal cell above described, and usually, though not always, is bent across the receptacle instead of diverging outward, often at right angles to the axis of the receptacle, as is usually the case in *D. Anisolabis*.

Dimeromyces Forficulae Thaxter.

L. c. **389**, 1902. Monograph. Part 2, 242, Plate XXIX, figs. 9–11. Spegazzini Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 515, fig. 56.

This species, which occurs on *Doru lineare* (*Forficula taeniata*) in Central and South America, has been obtained from Mexico and Guatemala, and is reported from La Plata by Spegazzini. It is doubtless common wherever its host occurs, and may be taken as the type of the small group of forms on Forficulidae to several of which it is very closely allied. The most conspicuous difference which distinguishes it from its nearest ally, *D. Anisolabis*, is the character of the primary appendage in the male, and of the lower secondary appendage of the female; the basal cell of which, in the present species, is usually much longer and often curved, so as to turn the appendage across the receptacle; while the subbasal cell lacks the special modification which is so striking a character in *D. Anisolabis*.

Dimeromyces Prorei Thaxter. Plate X, figs. 265–267.

L. c. **55**, 274.

Male individual slender, hyaline. Receptacle of two cells; the basal several times as long as the subbasal, straight. Appendage slightly tapering; the basal cell hyaline, free; the subbasal slightly suffused, and distinguished by dark septa; the distal hyaline and variably elongate. Antheridium usually single, divergent, hyaline, except the very faintly suffused outcurved neck. Total length to tip of appendage, including rather large foot, 50 μ.

Female individual hyaline with yellowish to brownish suffusion. Receptacle rather short and stout; of four cells, the basal larger, short and subtriangular; the subbasal flattened and irregularly subtriangular; the third flattened and curved; the distal slightly compressed distally, and bearing the free appendage which may be, like that of the male, divergent, sometimes at right angles, relatively somewhat longer, of four or five cells; the subbasal distinguished by dark septa or its basal cell may bear, from its broadened distal surface, two or more branches of similar

character, or smaller. Secondary appendage single, arising from the subbasal cell, its base sometimes slightly geniculate, the irregularly prominent basal cell hyaline, distinguished by a dark septum and constriction from the rest of the appendage; the lower three or four cells hardly inflated, separated by slight but abrupt constrictions, rather deeply suffused with smoky brown; the extremity including two or three cells, the whole tapering throughout and variably divergent, Perithecium rather slender, nearly straight and erect, nearly isodiametric, or slightly inflated; the stalk not distinguished; the tip barely so; the apex abruptly narrower, and bent strongly inward; the inner lip slightly more prominent. Spores about 30 × 4 μ. Perithecium 65–80 × 8–9 μ. Receptacle 30–35 × 18 μ. Secondary appendage 80–105 μ. Total length to tip of perithecium 85–105 μ.

On the inferior surface of the abdomen and forceps of *Proreus simulans* Stal., No. 3134, Los Baños, Laguna, Philippines.

The hosts on which this species was found were kindly sent me by Dr. W. H. Weston, and were collected in the sheaths of sugar cane. It is well distinguished from its near allies, *D. Australasiae*, *D. Forficulae* and *D. Anisolabis*, by the character of its appendages and perithecium.

Dimeromyces minutissimus Thaxter.

L. c. **41**, 204, 1905. Monograph, Part 2, 242, Plate XXIX, figs. 6–9.

This species, which is common on *Labia minor* Burm. in the vicinity of Cambridge, has not been received from other localities. It is, however, undoubtedly abundant wherever its host occurs.

Dimeromyces Lapiae Thaxter.

L. c. **41**, 303, 1905. Monograph, Part 2, 242, Plate XXIX, figs. 1–5. Spegazzini, Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 516, fig. 58.

This species which, although closely allied to the preceding, seems to differ from it in important respects, has been found but once on the elytra of *Labia minor* near Cambridge: but is also reported by Spegazzini, on the same host, from La Plata.

Dimeromyces lobatus Thaxter. Plate IX, figs. 229–231.

L. c. **55**, 280.

Male individual hyaline, with faint brown tinges. Receptacle of three cells; the basal abruptly more than twice as broad distally, its extension forming a shelf-like support for the flattened, subtriangular, slightly oblique subbasal cell, as well as the base of the lower antheridium, when two are present; the third cell smaller and narrower, oblique below, slightly larger than the undifferentiated basal cell of the erect appendage, which is separated from the distal, slightly tapering, three-celled portion, by a thick black septum and slight constriction; a second similar branch, from the basal cell separated by a black septum, may also arise slightly higher on the inner side. Antheridium arising from the third, sometimes also from the subbasal cell of the receptacle, its axis parallel to, and in close contact with, the appendage which it slightly exceeds; rather long and narrow, the stalk cell short and free, externally convex, the neck relatively long and rather abruptly distinguished, curved slightly outward. Total length, including foot, (18 μ), 65 μ. Basal cell × 8 μ below; × 114–16 μ distally.

Female individual similar to the male, the receptacle of four cells; the basal cell of the terminal primary appendage subspherical, undifferentiated, separated from the distal portion by a dark septum and slight constriction. Secondary appendages dimorphic; one from the distal cell

somewhat similar to the primary, but longer, of six or seven cells; the second from the subbasal cell much larger and stouter, externally and distally blackened, its basal cell short and irregularly rounded, separated from the stout straight four-celled distal portion by a blackened septum and deep constriction, its terminal cell giving rise to usually four short irregular, blackish brown branches or lobes, recurved outward. Perithecium arising from the third cell, its stalk well developed, the ascigerous portion immature. Primary appendage 25–50 μ; lower, secondary, 40–50 μ. Receptacle, including foot, 40–50 μ.

On the forceps of *Echinosoma congolense* Borelli, No. 3104, Kamerun, W. Africa.

About twenty individuals of this very peculiar species, among which only the males are fully mature, have been examined. Although I have described it with reluctance, owing to the fact that the perithecia are not fully developed, the characters of both sexes are such that its confusion with any other form seems improbable. No other species, as far as is known, shows the slightest tendency to produce the very peculiar terminal lobes, or branches, from one of the secondary appendages, and it is thus quite unique in this respect.

Dimeromyces moniliformis Thaxter. Plate IX, figs. 221–223.

L. c. 55, 278.

Male individual nearly hyaline, straight; the receptacle of three small somewhat similar cells, continuous with the straight, erect, relatively stout, tapering appendage; the basal cell of which is undifferentiated, and separated by a thick black septum and constriction from the hardly smaller subbasal cell; which is itself separated from the similar cell above it by a thin black septum; the terminal cell longer and somewhat tapering, exceeding the tip of the antheridial neck. Antheridium abruptly erect, its axis parallel to that of the receptacle and appendage, the neck rather short and stout, slightly tapering, and curved outward, the stalk-cell slightly prominent externally, subtended by a prominently rounded somewhat flattened cell, slightly larger than the subbasal cell of the receptacle, opposite which it lies, and extending downward below the extremity of the basal cell. Antheridium about 22 × 6 μ. Appendage and receptacle, including foot, 50 μ.

Female individual nearly hyaline, with faint tinges of purplish brown. Receptacle lying prostrate, as does that of the male; of four somewhat flattened cells, not dissimilar in size, the second and third wedge-shaped. Primary appendage similar to that of the male, its basal cell more nearly round. Subbasal cell of the receptacle bearing the single highly differentiated secondary appendage, the basal cell of which overlaps that of the receptacle, and is externally strongly prominent and rounded, its distal end bent abruptly upward and outward to join the rest of the appendage; which is erect, slightly curved outward, submoniliform, consisting of seven or eight cells; the four lower smaller, hyaline, or the upper slightly suffused, distinguished above and below by deep constrictions and thick black septa, oblique above; the remaining cells successively larger; the lower nearly round; the distal subdivided. Perithecium slightly curved inward, erect, its general axis at right angles to that of the receptacle and primary appendage, normally single, arising from the third cell of the receptacle; the stalk-portion hyaline, short, hardly distinguished; the sporiferous portion but slightly broader in the middle region, long, slender, pale translucent reddish brown, distally curved slightly inwards, the outlines broken by four successive, rather prominent, rounded enlargements, the upper less marked and involving the tip; which is slightly bent inward, rather broad and flat, and asymmetrically slightly sulcate. Spores about 30 × 4 μ. Perithecia 125–145 × 12–20 μ. Primary appendage 25–34 μ; secondary 100–110 × 8 μ at base, × 12 μ distally. Total length to tip of primary appendage 58–66 μ.

On the forceps of *Labia mucronata* Stal., No. 2139a, Sarawak, Borneo.

A very beautiful species, clearly distinguished from others related to it on Forficulae, by the moniliform base of its secondary appendage, and the wavy margins of its perithecium, which result from the presence of four successive enlargements. The perithecium is solitary in all the individuals examined, but the fourth cell of the receptacle cuts off a small cell, which possibly may sometimes develop a second perithecium or appendage.

DIMEROMYCES CHAETOSPANIAE Thaxter. Plate IX, figs. 224–228.

L. c. 55, 276.

Male individual rather short and stout; the basal cell becoming almost wholly blackened; the subbasal minute, subtriangular, and separating externally a much larger cell, which is rounded distally and forms an abrupt prominence below the base of the single antheridium; the third, terminal cell twice as long as broad, extending down beside the basal and distal, giving rise to the antheridium and primary appendage. The small stalk-cell of the antheridium not free; the venter erect, relatively large, stout and nearly symmetrical; the neck shorter; the very broad base hardly distinguished from the strongly outcurved distal portion. The basal cell of the appendage bearing terminally a three-celled branch, erect beside the antheridium, its basal cell distinguished above and below by a blackened annular septum, and sometimes subtended externally by a second similar branch. Total length to tip of antheridium, including foot, 35–38 μ. Antheridium 15–17 × 7 μ.

Female individual somewhat blackened above the foot, the suffusion involving part of the basal and the third cell. Receptacle at first somewhat spathulate, becoming prostrate; compact, four-celled, the fourth and the subbasal cell nearly opposite, at first similar, separated by the small narrow third cell. The latter bearing the single perithecium, its lower half in contact with the basal cell; the subbasal cell bearing a secondary appendage, the basal cell of which is nearly as large, and externally prominent below a four-celled branch, the two lower cells of which are shorter and distinguished by black septa; the fourth cell giving rise to the primary appendage and beside it, or slightly below it, to a second secondary appendage; which may be simple, or bear two three-celled branches from its basal cell, the two lower cells distinguished by black septa; the primary appendage simple, or its basal cell bearing distally and externally two or three two-celled branches, their basal cells distinguished by dark septa, somewhat shorter. The receptacle with its branches lying, at maturity, in the same plane, and viewed edgewise; the perithecium, which projects upward from the prostrate receptacle, arising from the small third cell at an angle of about 45°, relatively stout; the stalk about as long as the body, and often not very clearly distinguished from it; the tip slightly and abruptly bent inward, broad, snout-like, inconspicuously sulcate. Spores about 20 × 3 μ. Perithecium, including stalk, 75–130 × 13–15 μ. Appendages, including basal cell, 20–30 μ. Receptacle seen edgewise, including foot, 28 × 20 μ.

On the inferior surface of the abdomen and forceps of *Chaetospania thoracica* Dohrn. No. 2126, Sarawak, Borneo.

It is quite impossible to determine the cell-relations in fully developed female individuals; since the face view is never seen, and the early misplacement becomes accentuated. The above description is therefore based to a considerable extent on an examination of very young individuals in which the perithecium has but just begun to form as in figures 226 and 227. In the male, a small triangular cell is present, which appears to represent the subbasal cell, and it has been assumed that from this has been separated the much larger cell which forms a prominent rounded protrusion below the base of the antheridium. It is most nearly related to *D. appressus*, which

it resembles in general appearance; but may be at once distinguished by the peculiarities of its appendages, with their black-septate branches, and by the stouter perithecium.

Dimeromyces appressus Thaxter. Plate X, figs. 255–258.

L. c. **51**, 8.

Male individual more or less tinged with brownish, the basal cell larger and forming a rounded prominence below the base of the antheridium, from which it is separated by a deep indentation; subbasal cell subtriangular, rather deeply suffused externally, bearing the antheridium and suberect appendage; the latter consisting of four cells; the basal longer than broad; the subbasal squarish, the lower septum black, the distal paler; the third cell similar in size; the distal longer than the two combined, and tapering slightly. Antheridium erect, the venter externally convex, the base of the neck stout, purplish brown, abruptly distinguished, slightly tapering; the short hyaline extremity abruptly bent outward. Receptacle, without foot, 10 × 9 μ. Antheridium 18 × 6 μ. Appendage 20–24 μ. Total length to tip of appendage about 30 μ.

Female individual with prostrate receptacle, its four cells becoming more or less deeply suffused, more or less conspicuously prominent above the base on the side away from the substratum; the subbasal bearing the single secondary appendage, which may lie parallel to the substratum and primary appendage, or may diverge in the opposite direction from the base of the perithecial stalk, its basal cell relatively long, separated by a distinctly blackish, sometimes oblique septum from the three shorter, distally somewhat tapering, terminal cells. Primary appendage like that of the male. Perithecia solitary, arising from the minute third cell, the long, rather slender stalk projecting upward vertically, or at an angle from the substratum, broader immediately above its origin, somewhat longer than the purplish brown body of the perithecium, which may be rather evenly fusiform, or somewhat asymmetrical; the tip not distinguished, except near the apex, which is subtended externally by a more or less well defined prominence; the lips variably and unevenly prominent, slightly oblique. Perithecium, ascigerous portion, 45 × 12 μ: the stalk 70–80 × 12 μ at base. Spores about 28 × 2.5 μ. Receptacle, including basal cell of appendage and foot, 20 × 10 μ. Primary appendage, without basal cell, 12–16 × 5 μ. Secondary appendage 35–45 × 5.5 μ.

On the inferior surface of the abdomen and forceps of *Labia pilicornis* Motsch., No. 2112, Peradeniya, Ceylon, (Type). On *L. curvicauda* Motsch., No. 2414, Manila, P. I. On *Labia* sp., No. 2871, Emperor and St. Ann's Valleys, Port of Spain, Trinidad, B. W. I.

Owing to its small size, early suffusion and distortion, it has been almost impossible to determine the exact structure and cell-relations in the receptacle of the female of this species, which, lying prostrate on the substratum is almost invariably viewed edgewise, as is the case with its near ally *D. Chaetospaniae*. In the male, the receptacle appears to consist of not more than two cells, and there is no indication of the small triangular cell which I have assumed to be the subbasal cell in the last mentioned species. Female individuals, figure 255, growing on the forceps of the host, differ from those on the abdomen in the position of the appendages, which are parallel in the one case, and diverge in the other, the secondary being bent upward and away from the base of the perithecium, as in figures 256–7.

Dimeromyces annulatus Thaxter. Plate X, figs. 251–254.

L. c. **55**, 279.

Male individual faintly tinged with brownish. Receptacle of two cells; the subbasal subtriangular, bearing the solitary antheridium laterally and obliquely, and the undifferentiated

basal cell of the erect, simple, three-celled appendage, the middle cell of which is squarish, and distinguished by dark septa; the distal several times as long, with rounded extremity. Antheridium rather stout, erect; the stalk-cell oblique; the venter somewhat inflated; the neck rather short and stout, strongly curved outward. Length to tip of appendage 28 × 7.5 μ. The antheridium 17 × 5.5 μ.

Female individual pale brownish, the receptacle short-spathulate or subtriangular, of four superposed cells, which become more or less displaced by an outgrowth of the third cell on the posterior side, and the enlargement of the basal cells of the appendages. Primary appendage of four cells; the subbasal short, somewhat narrower, distinguished by dark septa. The three terminal cells of the receptacle flattened and broad, slightly oblique, the third bearing the perithecium and protruding posteriorly; the second producing the first secondary appendage; while the fourth produces the primary appendage distally, and another secondary appendage laterally, above the perithecium: both secondary appendages distinguished below by the presence of broad, short cells, with dark annular septa; of which there may be five or six in the upper, and somewhat fewer in the lower; the terminations of both appendages hyaline, slightly inflated; their total length not half that of the perithecium, which is set between them, and from which they may diverge slightly. Perithecia straight, or very slightly curved, narrow, erect, slightly asymmetrical, distally tapering slightly to the blunt, somewhat asymmetrical apex; the ascigerous base abruptly broad above the almost obsolete stalk-region. Spores about 32 × 2.5 μ. Larger perithecia 56 × 10 μ. Primary appendage 20 × 5 μ: larger secondary 30 × 3.5 μ. Receptacle 13–15 × 13 μ. Total length to tip of perithecium about 70 μ.

On the inferior abdomen of *Chaetospania paederina* Gerst., No. 2205, Kamerun.

This minute species is most nearly related to *D. appressus*, which occurs on a similar host, but differs widely in its appendages and perithecium. The compact, relatively small receptacle appears quite differently from different points of view, and owing to a rounded outgrowth of the third cell, shown in figure 251, the fundamental cell-arrangement is often difficult to recognize.

SPECIES PARASITIC ON ACARINI.

Dimeromyces Galumnae Thaxter. Plate V, figs. 126–128.

L. c. **55**, 230.

Male individual slightly curved throughout, faintly tinged with brown, consisting of a three-celled receptacle, terminating in a simple two- to three-celled appendage, which is slightly longer, not abruptly distinguished, its two distal cells tapering somewhat, narrower and paler than the basal. Antheridium small, short, arising from the small subbasal cell; its very short subconical neck lying against the third cell, or turned sidewise; its venter hardly distinguished from the subbasal cell. Total length to tip of appendage 50–58 × 10 μ. Antheridium about 10 μ.

Female individual reddish brown: receptacle consisting of seven to nine cells, flattened and obliquely superposed, except the paler basal and the terminal ones: the third, fourth and sixth producing secondary appendages, which are short, straight, rigid horizontal, or bent upward; that from the second and third usually rudimentary or obsolete; the fifth producing the single perithecium which is recurved when young, later divergent and straight, or slightly curved inward; the long slender stalk rather clearly distinguished from the subsymmetrically fusiform body; the inner lip slightly flattened and higher; the tip rather long, darker, moderately well distinguished. Basal cell of the primary appendage concolorous with the receptacle, straight, slightly tapering, distally rounded, and abruptly distinguished from the nearly hyaline, narrower

distal portion; which consists of usually two shorter basal cells, and a greatly elongated distal one; which is flexed and nearly uniform in diameter, the extremity much stouter and usually subuncinulate. Perithecium, including stalk, 115–190 μ; the body × 15–19 μ, the stalk × 7.5–11.5 μ. Primary appendage, longest, 325 μ, its smaller diameter 3.8 μ, its basal cell 29–24 × 10–12 μ at base.

On the upper surface of *Galumna* sp., No. 2976, Lasema, Fiji Is., Mann Coll., M. C. Z.

This curious species is the only form as yet observed on orobatid mites, and grows prostrate on its host, the long-stalked perithecium projecting abruptly upward, and the singularly elongated primary appendage lying on the substratum. Only one of the three adult females examined is in perfect condition, and abundant material may show characteristics not above referred to. The male is also unusual in its characters, the very small short-necked antheridium appearing as if it were incorporated in the receptacle.

Dimeromyces subuliferus Thaxter. Plate III, figs. 75–78.

L. c. **55**, 232.

Male individual hyaline: receptacle of two very obliquely superposed cells, the upper slightly larger, and separated by a thick black septum and slight constriction from the two-celled appendage, the basal cell of which is slightly broader than long; the distal slightly longer and ending in a slender recurved extremity. Antheridium single; the stalk-cell small, and free externally; the venter short and stout, prominent externally; the neck uniform pale brown, its base rather broad and abruptly distinguished, bent inward obliquely across the appendage. Total length to tip of antheridium, including large foot, 50–55 × 10 μ.

Female individual becoming suffused with blackish brown above, the basal cell of the receptacle hyaline, variably elongate, forming a more or less well defined and abruptly distinguished stalk; the main body above it roughly suboval in outline: the subbasal, third and fourth cells subequal, somewhat flattened and obliquely superposed, forming a median series, and cutting off the large basal cells of the three lower secondary appendages, which are similar in general to the primary appendage of the male: the fifth cell giving rise to the perithecium and lying beside them, extending downward to the basal cell; the sixth cell parallel to it, distally united to the perithecium, as is also the large basal cell of a heterogeneous secondary appendage; the seventh, distal cell long-triangular, lying beside the sixth, not reaching to its base, and bearing the primary appendage distally, which is like the lower secondary, although no basal cell is separated. Heterogeneous appendage stiff, suberect, extending above the tip of the perithecium, tapering slightly, blackened, except the tip and the lower half of its abruptly swollen base. Perithecium stout, subsymmetrical, erect, or slightly tilted outward, broadly subovoid or subfusiform; becoming deeply suffused below, like the adjacent cells of the receptacle; the short truncate conical tip and apex rather well distinguished, the former suffused with brown, the latter hyaline. Perithecia 55–64 × 25–30 μ. Spores about 30 × 4 μ. Basal cell of the receptacle 25–42 μ. Heterogeneous appendage 38–42 μ. Total length to tip of perithecium 92–125 × 42–50 μ.

On a species of *Uropoda*, *sensu latiore*, No. 2692, Verdant Vale, Arima, Trinidad, B. W. I.

This species, which is more nearly allied to the others which grow on mites, is at once distinguished by its median, erect, blackened heterogeneous appendage, as well as by the very peculiar form of its other appendages, the slender terminations of which are characteristically recurved. The cell-structure is very compact, and less than half of the inner margin of the perithecium is free. The sequence and arrangement of the cells of the receptacle is quite unusual and misleading, and suggests that of some of the species of Rickia which inhabit similar hosts. A similar, but much less complicated arrangement, is also found in *D. Parasiti*.

In both the male and the female I have felt some uncertainty as to the number of cells which should be regarded as belonging to the receptacle, and it would perhaps have been better to consider the receptacle of the male as comprising only two cells, and that of the female only six, the third and seventh in either case representing the basal cells of the corresponding primary appendages.

Dimeromyces muticus Paoli.

Redia **7**, II, 293, Plate XII, fig. 10: Firenze, 1911. Malpighia, **24**, 339, 1912, Plate V, fig. 10.

This species, which occurs on *Canestrinia neglecta* Berl., a mite parasitic on *Scarabaeus centaurus* in Africa, is distinguished from allied forms on similar hosts by its large, stout, sessile perithecium, which is unarmed, with suffused tip and hyaline broadly spreading apex. The receptacle is three-celled, the basal much longer and irregularly curved, the subbasal subtending the large basal cell of the single secondary appendage, which is abruptly narrower and blackened above it; its six distal cells much broader, successively shorter, the tip disorganized. The primary appendage is similar, but shorter, with fewer cells; the two diverging somewhat symmetrically from the perithecium, which is inserted between them, its axis bent slightly outward. The characters of the male are not determined.

Dimeromyces mucronatus Paoli.

L. c. **290**, figs. 6–7; L. c. **336**, Plate V, figs. 6–7.

This species occurs on *Canestrinia spectanda* Berl., a mite parasitic on *Dorcus bucephalus* from Java. It is somewhat similar to *D. muticus*, but differs in its shorter perithecium, which lies close beside the secondary appendage, and is very broad distally, the apex minute, short, rounded, flattened, but abruptly distinguished, and subtended on the inner side by a short, bluntly conical, black, tooth-like appendage which projects inward nearly at right angles. The two appendages are similar in general to those of *D. muticus*, and similarly divergent; their basal cells much larger, that of the secondary three times as long as broad, the black suffusion above it extending almost to the tip. The basal cell of the primary appendage nearly twice as long as broad, distally symmetrically and broadly rounded, the blackened portion above it very abruptly narrower, median, the appendage distally considerably broader, the terminal cells small and nearly round. The characters of the male are undetermined.

Dimeromyces falcatus Paoli.

L. c. **292**, Plate XII, figs. 8–9 bis. L. c. **338**, Plate V, figs. 8–9 bis. Nec *Dim. falcatus* Thaxter, Proc. Am. Acad. Arts & Sci. **51**, 4, 1915.

This species occurs on *Canestrinia dorcicola* Berl., var. *Pentodontis* Berl., in Italy. It is similar to the two preceding, but smaller and more slender; the basal cell long and slender, the two remaining cells of the receptacle, and the basal cells of the two appendages, relatively small, and more or less similar in size and form. The appendages, which diverge from the base of the perithecium at somewhat less than a right angle, are straight, stiff, blackened nearly to the tips, the two terminal cells abruptly much broader; the secondary appendage considerably longer. The perithecium is relatively short, somewhat inflated below, distally suffused, the suffusion extending upward into a relatively long black process, slightly broader at its base, and with a blunt hyaline tip, which is rather strongly curved inward above the small, rounded, hyaline, subtending apex. The characters of the male are undetermined. Neither of these three species have been seen by me.

Dimeromyces Parasiti Thaxter. Plate IV, figs. 79–83.

L. c. **55**, 230.

Male individual hyaline, relatively long and slender, consisting of a relatively very large basal cell, with large foot; the subbasal cell much smaller, twice as long as broad, united to the stalk-cell and venter of the antheridium, which lies nearly parallel to it. Basal cell of the appendage squarish, undifferentiated, separated from the very short, pointed, two-celled distal portion by a broad black suffusion. Stalk-cell of the antheridium small, and free only externally; venter short, stout, externally convex; base of neck large, broad, faintly brownish, passing into the very long neck, which is concolorous, except the hyaline extremity, bent inward and slightly upward. Total length about 40 μ. Appendage 5.5 × 4.5 μ. Antheridium, venter 12 × 6.5, neck and base 24 × 2.5 μ.

Female individual hyaline, except the brown appendages. Receptacle of four or five cells, the one or two above the large basal cell very small, and displaced so that the next succeeding cell above lies beside it, or them, and is also in contact with the basal cell; the distal cell smaller than the cell below, oblique, with somewhat rounded outline, obliquely separated from the free basal cell of the primary appendage; which is more than twice as long as broad, nearly uniform in width, and separated by a thick black septum and constriction from the distal brown portion; the lower half of which is broader than the upper, the extremity abruptly vesicular, hyaline and contrasting. Secondary appendages one or two, similar to the primary, or slightly longer. Perithecium single, sessile between the two diverging appendages, about half of its margin, below the apex, united to the inner margin of the basal cell of the adjacent appendage; stout and relatively short, subsymmetrical; the lower half broader, somewhat inflated, tapering to the well distinguished tip and apex; the latter broad, of even diameter, the distal margin flattened, rounded, slightly sulcate, with a slight prominence on either side, the anterior somewhat lower. Spores 30 × 3.8 μ, the apical segment very short. Perithecia 58–68 × 22 μ. Primary appendage 75–80 × 8 μ, its basal cell 15–21 μ; free portion of upper secondary appendage 54–56 × 8.5 μ. Total length to tip of perithecium 100–125 μ.

On *Parasitus* sp. and *Machrocheles* sp., No. 2493, Orizaba, Mexico, M. C. Z. (Mann Coll.).

This species is closely allied to those described by Paoli and is most nearly related to *D. muticus* Paoli. It has a similar V-shaped habit, but differs in numerous details of structure, and is perhaps most readily distinguished by the union of the lower half of the perithecium with the basal cell of the subtending secondary appendage. The arrangement of the cells of the receptacle is quite misleading, since the last, or the last two which are separated from the basal cell, are very small and the wall which separates them from the basal cell does not reach the outer margin of the latter, figure 81, so that as the subterminal cell above them enlarges, they assume a position beside it and seem to be accessory. Figure 97 shows the more usual condition in which but one secondary appendage is present, subtended by the very small subbasal cell, which corresponds to the small triangular cell above the basal in figure 81. A similar and even more confusing displacement is seen in *D. subuliferus*, in which the three cells last separated from the basal are superposed beside the fifth, from which the perithecium arises, figure 76.

EUDIMEROMYCES Thaxter.

L. c. **54**, 215, and **55**, 272.

Type Species *Eudimeromyces Chiliotis*.

Male individual consisting of three superposed cells, terminated by a single antheridium, within which one or two antheridial cells may be distinguished.

Female individual similar to the simpler types of *Dimeromyces* in structure.

In a recent Contribution on New Dimorphomyceteae (l. c. **55**, 272), I have mentioned that a reexamination, with high magnification, of stained specimens of the males of this form, has indicated that the contents of the supposed antheridium may appear longitudinally divided, as in figure 281; and is thus possibly to be regarded as a compound antheridium of a reduced type, somewhat similar to that present in *D. Tomari* and *D. aberrans*. If this is true, the only basis for the separation of the genus from *Dimeromyces* would rest on the strictly terminal position of the antheridium, which would have no parallel in the last mentioned genus. Although, in the two species referred to, the presence of two antheridial cells can be clearly made out, the same cannot be said to be true in the present instance, in which the apparent longitudinal division of the cell-contents may be a misleading artifact. The form of the cell is certainly suggestive, and it has the appearance of being distally perforate. It is possible, however, that it is merely a sterile cell, terminating the axis, like that of *D. aberrans*, which is also shaped much like an antheridium, figure 285, and that, in certain individuals, a compound antheridium may be produced in the usual lateral position. But although about a dozen of these supposed males have been examined, in no instance has any indication of a development of this nature been seen. That it is a unisexual form is placed beyond question by the structure of its mature perithecium, the cavity of which is continuous from base to apex, and it seems also certain that it is very closely allied to *Dimeromyces Tomari*.

Eudimeromyces Chiliotis Thaxter. Plate X, figs. 279–281.

L. c. **54**, 216.

Male individual hyaline slender, the cells nearly uniform, the neck and venter of the antheridium about equal in length, well distinguished. Total length 25 × 4 μ. Antheridium 12 μ.

Female individual hyaline, or slightly yellowish. Receptacle irregularly triangular; consisting of a subtriangular basal cell, and usually four others, disposed so as to lie above it in a more or less horizontal series; the subbasal cell enlarged and variably protruding; the fourth and fifth smaller, giving rise to the single perithecium and the primary appendage, respectively. The appendage undistinguished, somewhat irregularly tapering, usually exceeding the tip of the perithecium. Perithecium thick-walled, the stalk broad, about half the length of the ascigerous portion, which is undistinguished from it; tapering to the undifferentiated tip and rather broad, flat or rounded apex, which are nearly symmetrical. Spores about 20 × 2.6 μ. Perithecia 65–70 × 14–15 μ. Receptacle 14–17 × 11–13 μ. Appendage, longer, 110–120 × 8 μ. Total length to tip of perithecium 80–100 μ.

On *Chiliotes formosus* Reit. ,No. 1473, Baños de Apoquindo, and No. 1898, Corral, Chile.

Eudimeromyces andicola (Spegazzini) Thaxter.

L. c. **55**, 273.

Corethromyces andicola Speg. Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires **29**, 487, fig. 29.

Male individual unknown.

Female individual hyaline. Receptacle compact, of four (or five ?) cells, the second and third larger and obliquely superposed. The appendage broader and more closely septate distally, tapering at the extremity, nearly twice as long as the perithecium. The stalk of the perithecium long and slender, straight and stiff; the ascigerous portion nearly symmetrically inflated, tapering downward from about the middle to the insertion of the stalk, the blunt sub-

conical tip and apex slightly bent outward. Perithecuim, sporiferous part, 55–62 × 19–22 μ: stalk 60–65 × 7–15 μ. Receptacle 45 × 18–20 μ. Appendage 175–200 × 10–15 μ.

On *Chiliotes formosus*, Nahuel-Huapi region, Neuquen, Argentina.

This species, the male of which was not observed by Spegazzini, seems to correspond in all essentials to the type of this genus, although specifically quite unlike *E. Chiliotis*. It is of course possible that, like this species, it may have eventually to be removed to *Dimeromyces;* but the structure of its perithecium, as figured by Spegazzini, shows very clearly that it is unisexual and cannot belong to the genus in which it was originally placed. The above description is based on the figure and description given by Spegazzini. I have not myself seen specimens.

CHITONOMYCES Peyritsch.

Sitz. d. k. k. Acad. Wiss. Wien: **68,** 250, 1873.
Heimatomyces Peyritsch. l. c. 251. Thaxter, Proc. Am. Acad. Arts & Sci., **26,** 30.

Type Species *Chitonomyces melanurus.*

Although this genus is here considered apart from its natural sequence it has been found convenient, for mechanical reasons, to include it before taking up *Trenomyces*, the only remaining member of the Dimorphomyceteae. The species are all confined to aquatic beetles belonging to the Haliplidae and Dytiscidae, the last mentioned family including hosts of all but four of the known forms.

The generic type seems to correspond to that of the two aquatic genera *Hydraeomyces* and *Limnaiomyces,* while the latter is evidently very closely related to *Peyritschiella* and its near allies. This relationship is most strikingly suggested by the peculiar type of appendage present in all these instances, and consisting of two cells; the basal, which in the present genus is characteristically bell-shaped, bearing a more slender, unicellular, terminal portion; from which it is separated by a more or less evident constriction and blackened septum; and which is ordinarily slender, cylindrical and colorless. The character and arrangement of the cells of the receptacle is similar, in general, to that of the two last-mentioned genera; both of which differ, however, from the fact that additional appendiculate cells are distally separated in both cases. Although in *Limnaiomyces* a well defined compound antheridium is present, similar to that found in *Peyritschiella* and its near allies, nothing which can be regarded as clearly corresponding to such an organ has been seen in either *Chitonomyces* or *Hydraeomyces.*

The species of the present genus seem to fall readily into two well defined sections, which are distinguished by the fact that all of those which occur on hosts other than the Laccophili among the Dytiscids, bear but a single primary appendage, the basal cell of which, cell *i*, terminates a six-celled receptacle, as in figure 330; while in all other species there seem always to be eight cells present in addition to cell *i*, the fifth cutting off the basal cell, *h*, of a secondary appendage, which arises in the angle between the perithecium and the primary appendage, as in figure 387; the third, fourth and fifth associated more or less horizontally above the subbasal cell. I have formerly been mistaken, I think, in supposing that the simpler of these types, represented in figures 330 and 332, for example, was probably identical, except for the separation of a secondary appendage; since an examination of more abundant material of various species having a primary appendage, only, leads me to believe that its receptacle cannot be regarded as consisting of more than six cells; the three cells which I have formerly distinguished as cells *c*, *d*, and *e*, being replaced by two, cells *c* and *e*, as indicated in the figures last cited; the small cell subtending the base of the perithecium externally, being merely one of the basal cells of the latter, and not belonging to the receptacle.

With reference to the possible sexual characters of the genus, I regret that I have been unable to reach a satisfactory conclusion. In a few young individuals, somewhat younger than the stage represented by figure 333, I have sometimes seen what appears to be a short, hyaline, evanescent structure, which may perhaps correspond to a trichogyne, the base of which is often distinctly suffused, and persists beside the dark septum of the secondary appendage, if this is present; or in a corresponding position, as shown in the figure last cited, where its connection with the carpogenic cell of the young perithecium, which has been seen in various other instances, seems evident. In mature individuals of certain species, this persistent base seems to be replaced by a definite, somewhat indurated outgrowth; as in *C. cerviculatus*, *C. rhyncostoma*, *C. Grenadae* and *C. uncinulatus*. The trichogyne, if it is present, is extremely evanescent, and though I have seen several instances in which a connection between this "persistent base" and the carpogenic cell could be as clearly seen as it is in figure 333, I do not feel, from such observations as I have been able to make, that it is possible to arrive at any definite conclusion as to the presence or absence of a receptive female organ.

With reference to a male organ, I am also obliged to confess that, although one is so clearly distinguished in *Limnaiomyces*, I have seen nothing which can be thus interpreted in the present genus; and think it not improbable that, as is probably the case in several other instances among the Laboulbeniales, functional sexuality has been lost, and with it all trace of a male organ. The whole question, however, needs a much more careful and extended examination of fresh and stained material than I have been able to give it, and further investigation may show that the structures in question have been overlooked or misinterpreted.

The specific differences, which separate the various species of the genus, are based upon size, which is unusually constant; general form and cell-arrangement and, in many species, on peculiar modifications of the cells of the perithecium and of the receptacle, or outgrowths from them, some of which are very striking, as in figure 309. More or less contrasting suffusions of special cells or regions, as in figures 324 and 327, and more rarely the presence of verrucosities or characteristic roughening of the surface, as in figures 299, 306 or 312, are also occasionally distinctive.

The forms growing on Halipli and Laccophili are very remarkable in another respect, to which references has been made several times in previous papers, in that the distribution on its host of a given species is extraordinarily limited; and the restricted area of attachment in each case corresponds very exactly, in different host-individuals, even when the latter are quite different species, inhabiting widely separated regions. Not only will the distance from the apex of the elytron, for example, of the restricted area occupied by a given species, always be the same; but its relation to either margin will be definitely fixed. Of species inhabiting the left elytron, none will be found even in a corresponding position on the right. Thus if one sees, we will say, five groups along the outer margin of the left elytron, at different distances from the apex and from the extreme edge, on a given *Laccophilus* from a locality in which its flora is known, he can be sure that he has before him five different species, the identities of which he can thus determine without microscopic examination.

It is also remarkable that, in certain specific types, like that which includes *C. melanurus*, *C. japanensis*, *C. helicophorus*, *C. javanicus*, and at least one other, as yet undescribed, or the closely related group which includes *C. seticolus*, *C. bicolor*, *C. prolongatus* and *C. marginatus*, the members inhabit definite and similar positions, in these instances at or near the margin of the distal fourth of the left elytron. Not only are individual species, therefore, definitely restricted to very limited areas, but the same is true of different species of the same general specific type.

This restriction as to position of growth does not appear to hold in all other instances among the parasites of Dytiscidae, since individuals of *C. Hydropori*, for example, which inhabits

a host having habits quite similar to those of *Laccophilus*, has been found on the margins and on the middle of the elytra, as well as on the inferior surface of the abdomen, and is certainly not restricted in its distribution. A further indication that the ordinary habits of the insect host are not responsible for this fixity in position is found in the case of species that occur on Halipli; which, like *C. Bullardi*, are quite as definitely restricted: although these somewhat inactive insects, which tend to creep slowly on rather slender legs, are distinctly different, in this respect, from the active and swiftly swimming species of *Laccophili*. That the habits of the host are not responsible for the condition, is also shown by the fact that the closely allied *Hydraeomyces*, which is also found on Halipli, occurs indiscriminately on the legs, elytra, abdomen and thorax.

It may be mentioned that all the forms which do not seem to be thus restricted, belong to the section having no secondary appendage, and occur on Dytiscidae having habits much like those of *Laccophilus*, although several are very minute. It might be suggested that, in the case of the restricted forms, a slight difference in the character and amount of the nutriment obtained from different areas of the elytra, for example, might influence the successful growth of a given species. But the fact that, in one instance, I have found a few specimens of *C. marginatus* normally developed near the tip of the left leg, would indicate that this is not a tenable theory. I have previously suggested that automatically recurrent movements of the legs *in coitu* might serve to explain the mechanism of spore-transfer to and from definite points; but, if this were the true explanation, all the species thus transferred ought also to be found growing in various positions on the legs.

Many examples of a similar nature might be cited, which occur, in individual cases, among other genera of Laboulbeniales; for example *Laboulbenia umbonata*, *L. lepida* and *L. elegans* which, with various others, are always found in a certain position on the thorax; but in no other instance is this phenomenon so striking as in the present genus, and I feel quite unable to offer any plausible explanation of it.

Some of the outgrowths from the perithecium and even from the cells of the receptacle, figures 309, 313, 315, etc., are probably to be regarded as what I have formerly described as "trigger organs," remarkable instances of which occur in *Ilythea*, *Ceratomyces* and other genera; all of which are so arranged as to affect the tension within the perithecium, on contact with another host or any firm object, in such a manner as to induce a sudden discharge of spores, the advantages of which are obvious. Perhaps the most striking instance of this kind is seen in *C. longirostratus*, figure 324, in which the cells which form the tip are enormously elongated, forming a slender somewhat indurated tube. It seems evident that when this tube is struck, as at the moment of impact with another host, so that even a very slight lateral bending is produced, the body of the perithecium, at its base, will be correspondingly compressed, with a resultant spore discharge, at the psychological moment. A similar purpose is also served, in all probability, by the elongation of the upper tiers of cells in the perithecium of many species of *Stigmatomyces*.

It will be seen from the following enumeration that fifty-five species of *Chitonomyces* are thus far known from various parts of the world, in addition to two which are here removed to another genus, a great majority of them having been found on the dytiscid genus *Laccophilus;* four occurring on Halipleae, and the remainder on Dytiscidae of genera other than *Laccophilus*. I have endeavored to arrange the species serially, and to associate evidently related forms, as far as practicable; but, as in any serial arrangement in a rather large genus, this attempt has resulted, necessarily, in the juxtaposition, in certain instances, of unrelated forms.

The species have been divided primarily into two Sections: the first, which I have thought it worth while to designate as *Euchitonomyces*, including those forms in which the receptacle consists of but six cells: a basal, *a*, and subbasal, *b*, followed by two horizontally, associated, *c* and *c;*

and two lying beside the perithecium, cells *f* and *g*, and below the basal cell, *i*, of the primary appendage. In the second Section, containing those species which conform to the structure of the Type, all those forms are included in which a secondary appendage is present and in which the receptacle consists of eight cells, this number including, for convenience, the basal cell of the secondary appendage which is lettered *h*, the rest being lettered from *a* to *g*, beginning with the basal cell and ending with the distal which subtends the basal cell, *i*, of the primary appendage (see These Proceedings, **52**, 3). Cells *d* and *h* are thus absent in Section A, otherwise the corresponding cells are similarly lettered in both cases.

Section A. Euchitonomyces.

Receptacle of six cells. Secondary appendage lacking.

Chitonomyces bidessarius Thaxter.

L. c. **28**, 185. Monograph, Part 1, p. 292, Plate XXVI, figs. 4–5.

This small species has been found in the type locality, Kittery Point, Maine, on *Bidessus granarius* Aube, and forms which cannot be satisfactorily separated from it have been received from Labasa, Fiji Islands, No. 2962 (Mann Coll.), and from Okayama, Japan, No. 2941, Mr. Chung; in both instances on minute dytiscids.

Chitonomyces borealis Thaxter.

L. c. **28**, 195. Monograph, Part 1, p. 292, Plate XXVI, figs. 8–9.

Since its original collection on Cutts Island, Kittery Point, Maine, on *Desmopachria convexa* Aube, this species has not again been found.

Chitonomyces Australasiae nov. sp. Plate XI, figs. 300–301.

Pale straw yellow with a faint brownish tinge. Basal cell usually bent forward, nearly twice as long as broad; the subbasal very small, distinguished by slight constrictions, flattened, separated from the base of cell *f* and of the perithecium by two somewhat elongated, parallel, subsimilar cells, above the posterior of which cell *f* is obliquely separated and is externally overlapped by cell *g*, so that only a comparatively small portion of its outer margin is free; cell *h* not separated from cell *g*, from which cell *i* is distinguished by a curved oblique septum; this cell being turned inward, its outer margin oblique and convex, so that the insertion of the appendage lies against the perithecium. Perithecium straight, rather symmetrically inflated, the free portion, somewhat less than half, erect, tapering subsymmetrically to the blunt, rounded, subsymmetrical, clearly distinguished apex. Perithecium about 85 × 23 μ, the free portion 35 μ. Distal portion of the receptacle 60–66 μ; basal, including foot, about 70 μ. Total length to tip of perithecium, average, 130 × 23 μ.

On the margin of the right elytron, near the middle, of a small dytiscid. Viti Leon, Fiji Islands, No. 2961 (W. H. Mann Coll.).

Chitonomyces aurantiacus Thaxter.

L. c. **29**, 106. Monograph, Part I, p. 202, Plate XXVI, figs. 6–7.

This slender species is distinguished by its slightly orange color and the roughened outer margin of the perithecium. It occurs with *C. borealis* on *Desmopachria convexa*, and has not been seen since its original collection on Cutt's Island, Kittery Point, Maine.

Chitonomyces rugosus nov. sp. Plate XI, fig. 299.

Similar to *C. Australasiae* in general structure; cell *f* somewhat more overlapped by cell *g;* cell *i* less strongly bent inward. Perithecium about the same diameter from base to apex, the outer surface conspicuously rugose, or verrucose, the rugosities tending to run in transverse lines, the free portion very broad, bent strongly outward; its inner margin convex, the outer nearly straight; the apex distally nearly flat, subtended externally by a pale brown shade. Perithecium, average, 95 × 20 μ, the free portion 28 × 20 μ. Distal portion of the receptacle about 94 μ, lower portion 75–85 μ. Total length to tip of perithecium, average, 148 × 26 μ.

On the tip of the right elytron, near the middle, of a small dytiscid: No. 2961, Viti Leon, Fiji Islands (Mann).

This species was found in the position indicated on the same host which bore the preceding species. The two are very closely related, the present species being distinguished by the form of its perithecium, which is not only very broad and bent outward distally, but is conspicuously rugose externally.

Chitonomyces Hydropori Thaxter.

L. c. **38,** 32. Monograph, Part II, Plate XXXIV, figs. 28–29.

This species, which was originally collected by Mr. Charles Bullard at Cape Neddock, Maine, on *Hydroporus modestus*, has since been found at Kittery Point, Maine, and at Eustis, Florida. A form which does not appear to differ in any essentials, has also been received from Manila, P. I., on a dytiscid, at least allied to *Hydroporus*, which was sent me by Mr. Banks.

Chitonomyces inflatus Thaxter. Plate XII, figs. 331–332.

L. c. **52,** 15.

Form moderately stout; hyaline, becoming faintly yellowish; basal cell more or less conspicuously stained with blackish brown above the foot, hyaline and conspicuously inflated above: cell *b* small, somewhat or considerably broader than long, usually forming a distinct constriction of this region, which may be more or less geniculate; cells *c* and *e* much longer than broad, narrower below, distally distinguished by a slight indentation; cell *f* about half as long as the perithecium, and twice as long as cell *g*, from which it is obliquely separated; cell *i* normally longer than broad, its symmetrically rounded tip slightly narrowed. Perithecium relatively large and stout, curved outward, distally and somewhat pointed, its upper half free; the tip slightly distinguished and bent outward; the apex narrow, blunt, subsymmetrical, one of the lip-cells slightly prominent. Spores about 40 × 25 μ. Perithecium 75 × 25 μ. Total length to tip of perithecium 100–120 × 26–30 μ.

On the mid left leg of a *Clypeodytus pseudogeminus* Reg.. Manila, P. I., No. 2409.

This species is most easily distinguished by its inflated and more or less suffused basal cell, narrow subbasal cell and often geniculate habit in this region. The perithecium relatively large, its free inner margin strongly convex, its outer concave, or nearly straight; the termination bluntly pointed. It is more nearly allied to *C. Australasiae* and *C. rugosus* from which, as well as from other allied forms, it seems well distinguished by the characters above noted.

Chitonomyces incisus nov. sp. Plate XII, fig. 330.

More or less strongly curved throughout, relatively large, the concave margin anterior; hyaline, faintly tinged with yellowish. Basal and subbasal cells as in *C. Halipli* and *C. rugosus*,

cells *c* and *e* very large and long; cell *f* overlapped about half its length by cell *g;* cell *i* obliquely separated, and bent inward by the general curvature of the whole convex posterior margin: anterior margin mostly concave from base to apex. Perithecium about one third free; the tip and apex abruptly distinguished, on the inner side, by an angular elevation, which forms a subrectangular notch, subtending the apex; the distal margin of which is somewhat oblique, externally rounded, but which is otherwise nearly straight, short, broad and subuniform. Perithecium 85–95 × 25 μ. Distal portion of the receptacle 85 μ: cells *c–e* 45–60 μ. Total length to tip of receptacle 160–175 μ; of perithecium 170–190 × 38 μ.

On the inferior margin at the base of the left elytron of a small dytiscid. Viti Leon, Fiji Islands (Mann Coll.), No. 2961.

This relatively large species was found on a single host only, so that it is not possible to say whether its position of growth is characteristic or not. It is nearly allied to *C. Hydropori* and *C. rugosus*, but seems well distinguished by the inner prominence which subtends its apex, and the relatively large size of cells *c* and *e*.

Chitonomyces excavatus Thaxter. Plate XII, figs. 328–329.

L. c. **52**, 15.

Quite hyaline. Basal cell rather short and stout, not twice as long as broad; cell *b* flattened, horizontal; cells *d* and *e* similar large and long, the latter somewhat the largest; cell *f* about one half overlapped by cell *g*, the outer margin of which bulges abruptly above, its outer margin convex nearly to the insertion of cell *i;* which is erect, subsymmetrical and longer than broad. Perithecium relatively short, about one fourth free; the tip and apex curved abruptly outward above a large, broad, blunt, tooth-like, suberect projection which subtends it; the small, somewhat compressed apex, subtended on the inner side by a flattened elevation formed by a thickening of the wall. Spores about 45 × 2.5 μ. Perithecia 70 × 20 μ, exclusive of the tooth-like process which is subtriangular, 11 × 18 × 22 μ. Total length to tip of perithecium 120–150 × 30–35 μ.

On the margin of the right elytron of a *Clypeodictus pseudogeminus* Reg. Manila, P. I., No. 2409.

This species occurs on the same host with *C. inflatus*. It is perhaps most nearly allied to *C. incisus* which, however, lacks the tooth-like projection from the outer margin of the perithecium by which the present species is clearly distinguished from all others of this section.

Section B. (Chitonomyces proper.)

Receptacle of eight cells, secondary appendage present.

Chitonomyces simplex Thaxter.

Monograph, Part I, p. 292, Plate XXVI, figs. 1–3. *Heimatomyces simplex* Thaxter, l. c. **27**, 30.

This small species is common in New England occurring on the middle of the distal half of the right elytron of *Laccophilus maculosus*. It was originally said to occur also on *Hydroporus spurius*, but at the present time I am inclined to question whether there was not some confusion in the determination of the host in the case of this and of several succeeding species hereafter enumerated, which were among the first to be collected in this country over thirty years ago. The species was found on undetermined *Laccophili* at the Grand Etang, Grenada, and at Sangre Grande, Trinidad, B. W. I. and has been received from Guatemala (Kellerman); the individuals from these localities corresponding very closely to the more northern type. It is distinguished

by its small size, strongly curved habit, and the subtruncate, almost cylindrical or slightly tapering termination of its perithecium.

Chitonomyces Thaxteri Spegazzini. Plate XII, 326–327.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 480. *Chitonomyces elongatus* Thaxter, *nec* Spegazzini, l. c. **52**, 13.

Long, slender, curved, more strongly below; of almost uniform diameter throughout; evenly suffused with pale dirty yellowish brown, the basal cell more deeply tinged, and blackened along the anterior margin and above the foot; a deeply suffused region also, along the anterior margin of the tip, which merges into a more or less distinct transversely mottled area extending half way across the tip, on the right side. Basal cell rather long, slightly convex along its anterior suffused margin, obliquely separated from cell *b*, which it almost completely overlaps on the anterior face, and by which it is itself nearly one half overlapped on the opposite side; cells *d* and *e* relatively long, similar; cell *c* relatively small, overlapping the distal half of cell *d* and visible only on the left side; cell *f* very long and narrow, its base somewhat oblique, and but slightly overlapped by cell *g;* which is relatively long and narrow, slightly broader distally, and hardly longer than cell *h;* cell *i* more than twice as long as broad, bent against the margin of the perithecium some distance below the apex. Perithecium very long and narrow; the tip hardly distinguished, except by its suffusion; the apex well distinguished on the inner side, somewhat longer than broad, of uniform width, distally flattened, or bluntly rounded, with slightly projecting lips about the pore. Spores 40 × 2.5 μ. Perithecia 86–100 × 10–12 μ. Cell *i* 12 × 5.5 μ. Total length to tip of perithecium 120–55 × 12–16 μ.

On the tip of the right elytron of *Laccophilus* sp., Sangre Grande, Trinidad, B. W. I.

In general appearance this species nearly resembles types of *Euchitonomyces* like *E. Halipli* or *E. rugosus*. Cell *c* is quite invisible from the right, overlapping cell *d* obliquely, so that it is made out with difficulty. The secondary appendage, or rather its dark base, is clearly defined, however; as well as its basal cell, *h*. The individuals are apt to have a slight twist, so that it is not always possible to see the normal sequence of the cells. The present name was given by Spegazzini, owing to my regrettable carelessness in overlooking the fact that the name "*elongata*" had already been used in the genus.

Chitonomyces floridanus Thaxter.

L. c. **25**, 430. Monograph, Part II, p. 264, Plate XXXIV, figs. 36–38.

This species is known only from the types, which were found on *Cnemidotus 12-punctatus* at Eustis, Florida, inhabiting the legs and elytra. It bears a superficial resemblance to *Hydracomyces*, which grows on this host, but conforms strictly to the type of this section of the genus; cells *c*, *d* and *e* being clearly defined, and normally placed, when the right side is in view. It is an insignificant species, distinguished by the rather short, stout perithecium, with broadly rounded extremity, and more or less distinct papillate lips, recalling those of *Hydracomyces*, and by the usual prominence of cells *g* and *i*.

Chitonomyces occultus Thaxter.

L. c. **37**, 30. Monograph, Part II, Plate XXXIV, figs. 30–31.

This species, which grows on a species of *Cnemidotus*, concealed in a depression along the margin of the left elytron, near the middle, has not again been found. It is a small form dis-

tinguished by its narrow, bent, laterally suffused tip and small size, as well as by its position of growth and host.

Chitonomyces hyalinus Thaxter.

Monograph, Part I, p. 291, Plate XXVI, figs. 10–11. *Heimatomyces hyalinus* Thaxter, l. c. **26**, 31.

The types of this species were found on *Laccophilus* in the vicinity of New Haven, Connecticut, near the tips of the posterior legs. A form, apparently identical, was obtained on *Laccophilus*, in the same position, at the Grand Etang, Grenada, and what appears to be a long slender variety was found at Sangre Grande, Trinidad. The character by which it seems most easily recognized is seen in the unusual thickening of the rather straight anterior margin of the perithecium, which ends abruptly, forming a more or less distinct notch below the outcurved apex.

Chitonomyces affinis Thaxter.

Monograph, Part II, p. 291, Plate XXVI, figs. 12–14. *Heimatomyces affinis* Thaxter, l. c. **27**, 31.

The types of this species were found on the margin of the right elytron of *Laccophilus maculosus*, near the tip, collected in the vicinity of New Haven, Connecticut. It has also been obtained on the same host, and in the same position, from the vicinity of Cambridge, and from Kittery Point, Maine; as well as on *L. proximus* from Eustis and from Daytona, Florida. It is distinguished by its variably blackened, large basal cell, and the straight, strongly convergent basal cell of its primary appendage.

Chitonomyces uncinatus Thaxter.

Monograph, Part I, p. 291, Plate XXVI, figs. 23–24. *Heimatomyces uncinatus* Thaxter, l. c. **27**, 33.

This species is distinguished by its curved clavate habit, narrow apex, and especially by the upward prolongation of cell *g*, nearly as large as the tip and apex, and forming with them a socket in which the basal cell of the primary appendage is set. Specimens growing in the same position on *Laccophilus* sp., from the Grand Etang, Grenada, B. W. I., correspond very closely to the type, although somewhat more slender, No. 2687. Material from Sangre Grande, Trinidad, Nos. 280 and 281, although undoubtedly referable to this species, differ from the fact that the upgrowth above mentioned, and the tip of the perithecium, are more closely approximated, turning the basal cell of the primary appendage somewhat to one side, and from the conspicuous blackish brown suffusion of the basal cell.

Chitonomyces introversus Thaxter. Plate XII, figs. 322–323.

L. c. **52**, 6.

Short and stout, becoming roughly triangular, rather evenly suffused with dull brownish: basal cell relatively large, curved below and much broader distally; cell *b* very broad and flat, horizontal; cells *c* and *e* relatively small; cell *d* broad, flat-triangular; cell *f* long and narrow, with very thick outer wall, its extremity enlarged and, with cell *h*, bent abruptly inward at right angles; cell *g* lying horizontally above them, its base forming an external rounded prominence, its axis coincident with that of the basal cell of the primary appendage, which is somewhat round, and lies partly beside the tip of the perithecium, just above a shelf-like prominence, which subtends the tip on the left side. Perithecium broad and short; its short tip bent abruptly to the right, away from the subtending prominences; so that, when viewed from the right, it is seen end on;

the apex irregularly, rather coarsely lobed. Body of perithecium, exclusive of tip, 54–60 × 27–32 μ. Total length 80–95 μ, the three lateral dimensions 40 × 75 × 82–50 × 86 × 90 μ.

On the posterior legs of *Laccophilus* sp., No. 2687, Grand Etang, Grenada, B. W. I.

An apparently rare species, well distinguished by its short stout triangular form, and the horizontal position of the distal cells of the receptacle.

Chitonomyces italicus Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **27**, 46, fig. 12.

This species, which is otherwise very closely related to *C. manubriolatus*, appears to differ in the form of its appendage, developed from cell *g*, which bears a small subterminal branchlet or outgrowth. It appears to be nearly opaque, except the basal cell and the distal portion of the perithecium. It was found by Spegazzini on *Laccophilus obscurus* ?, at Conegliano, Italy.

Chitonomyces spinosus Thaxter.

L. c. **42**, 307. Monograph, Part II, p. 265, Plate XLI, fig. 40.

This form, which was obtained from a species of *Laccophilus*, No. 1394, from Java, on the left posterior leg, is closely related to *C. manubriolatus*, from which it differs in its pale color, longer and more uniform appendage, and rather long, nearly erect perithecium, ending in a small, compressed, nearly symmetrical apex.

Chitonomyces manubriolatus Thaxter. Plate XI, figs. 293–295.

L. c. **52**, 9.

Rather short, stout and subsigmoid in habit; brownish yellow, becoming more deeply suffused. Basal cell short, bent, obliquely overlapping the lower half of cell *b* on the posterior side; which is similar, or somewhat smaller, and, with cells *c–e*, more deeply colored; cells *c* and *d* subequal and subtriangular; cell *f* not very long, somewhat broader distally; cell *g* externally prominent in relation to an asymmetrically adjusted, variably divergent, straight or distally curved, thick-walled outgrowth; usually somewhat swollen above its base, and distally slightly tapering, its lumen connecting by a narrow isthmus with that of cell *g;* the whole forming a relatively long, free, deeply suffused appendage; cell *i* quite hyaline, longer than broad, slightly tapering and subsymmetrical, suberect. Perithecium stout, strongly convex externally, the margin somewhat undulate; the tip irregular, somewhat distinguished, curved inward, short, stout; the outer lip-cell of the apex forming a variably developed prominence, or outgrowth. Spores about 40 × 3.5 μ. Perithecium 75–25 × 27 μ, its appendage about 45 × 11 μ. Total length to tip of perithecium 125–145 × 40–45 μ.

On the posterior legs of *Laccophilus* sp., Sangre Grande, Trinidad, No. 2684, and at the Grand Etang, Grenada, B. W. I., No. 2687.

This species is nearly allied to *C. italicus*, and also resembles *C. spinosus* in having a well developed appendage, formed by an outgrowth of cell *g*. The type of *C. italicus* appears to have been immature, so that its characters are not all clear. It seems to be at once distinguished, however, by the fact that the appendage is distally furcate. What appears to be a rather extreme variation is illustrated by figure 295, which represents a form found on a species of *Laccophilus* from China, received from Professor Gist Gee. The points of contact of the four successive wall-cells along the strongly convex outer margin of the perithecium, are indicated by slight depressions which give the margin an undulate outline, which is often quite pronounced.

Chitonomyces gracilipes nov. sp. Plate XI, fig. 296.

Straight, erect, rather slender; faintly tinged with brownish; cells *a* and *b* of nearly equal length, the latter slightly stouter, deeper brown; the two forming a rather slender stalk: the region of cells *c–e* abruptly broader, cell *d* irregularly triangular, wholly included by cells *c* and *e*, which extend some distance above its upper angle and are subequal; cell *f* large and broad, oblique below; cell *i* erect, subsymmetrical, closely included between the perithecium and an erect prolongation of cell *g;* the lower half of which is broader, distally swollen with very thick external brownish wall, passing abruptly to the slender distally slightly incurved upper half. Perithecium considerably less than one half free, rather narrow, distally broader, the outer margin somewhat irregular, distally more convex; the inner erect, slightly convex; the apex blunt, erect. Perithecium 95 × 20 μ. Cells *a* and *b* 64 × 9 μ and 12 μ respectively. Upgrowth of cell *g* 44 × 8.5–4 μ below and above. Cell *i* about 16 × 8 μ.

On the subterminal joint of the right leg of *Laccophilus* sp., China, Professor Tsou comm.

A single specimen only of this species has been seen. It is allied to *C. manubriolatus*, but is readily distinguished by the character of the upgrowth of cell *g*, as well as by its general form, and the abruptly distinguished brown stalk formed by cells *a* and *b*.

Chitonomyces Grenadae Thaxter. Plate XII, figs. 317–319.

L. c. **52**, 7.

Tinged with dirty brownish, rather irregularly developed, with a slight twist. Basal cell not twice as long as broad; cell *b* somewhat flattened, rather clearly distinguished above and below by constrictions; cells *c*, *d*, *e* small and rounded, irregularly associated; cell *f* rather long and narrow, hardly overlapped by cell *g*, which projects free above the apex of cell *h* for a variable distance; forming, with cell *i*, from which it is not distinguished, an erect or but slightly curved, nearly uniform pseudo-appendage, its slightly asymmetrical somewhat pointed extremity bearing the basal septum of the filamentous appendage; the whole more deeply suffused, and reaching some distance above the apex of the perithecium. Perithecium rather misshapen, tapering more or less toward the base, where it is subtended by a variably distinct constriction; the second external wall-cell forming a thick, dark brown margin, broadening upward to a more or less pronounced double elevation, followed by an indentation, above which the tip is irregularly bent inward to one side: a variably developed curled appendage arises on the left side, opposite the apex of cell *h*, which may grow outward or sidewise, right or left, and is variably helicoid and pointed, otherwise of uniform diameter. Spores about 36 × 2 μ. Perithecia 55–60 × 14 μ. Cell *i* 28–30 × 7 μ. Total length to tip of perithecium 70–75 × 20–22 μ.

On *Laccophilus* sp., on the margin of the right elytron near the tip. Grand Etang, Grenada, B. W. I.

Allied to *C. rhynchostoma*, from which it differs in the irregular termination of its perithecium and the shorter free portion of cell *g*. It is slightly twisted, so that one has to examine it from different angles, as shown in the figures, to get a clear idea of its characters. Although the same host was obtained in great abundance in Trinidad, it was only observed on the Grenada material.

Chitonomyces rhynchostoma Thaxter.

Monograph, Part 1, p. 290, Plate XXVI, figs. 17–18. *Heimatomyces rhynchostoma* Thaxter, l. c. **27**, 33.

This species was originally found on *Laccophilus maculosus* in the vicinity of New Haven, Connecticut, and has been also found on an undetermined *Laccophilus* captured in the Aripo

Savanna, Cumuto, Trinidad, W. I. It grows near the middle of the margin of the right elytron, and is distinguished from the closely allied *C. Grenadae* by the longer, divergent finger-like extension formed by cells *g* and *i*, which are about equal in length; the former almost wholly free, and by the even, almost galeate, conformation of the tip of the perithecium. The peculiar curled outgrowth beside the apex of cell *h* is almost identical with that found in a similar position in *C. Grenadae* and in *C. cerviculatus;* in which, however, it occurs on the right, not on the left, side.

CHITONOMYCES CERVICULATUS Thaxter. Plate XII, figs. 320–321.

L. c. 52, 7.

Rather short and stout, subsigmoid, uniformly tinged with dirty pale yellowish brown, with certain deeper brown suffusions. Basal cell short and stout, the posterior margin convex; cell *b* broader than long, convex anteriorly; cells *c*, *d*, *e*, small, clearly defined, subtriangular, normal in position; cell *f* rather long, broader distally, where it is hardly overlapped by cell *g*, which bulges in an umbonate fashion on the right side, throwing the insertion of cell *i* asymmetrically to the left; and is short, broad and almost wholly free; cell *i* hemisphaerical; cell *h* short triangular: a short, rather stout, helicoid outgrowth arises near the apex of cell *h*, on the right side. Perithecium relatively rather large, its whole left side bulging, especially prominent distally, the long, stout, nearly uniform, neck-like terminal portion, which is turned slightly sidewise and then strongly inward, extending half its length beyond cell *i;* its lower, inner margin broadly suffused; the broad apex turned abruptly upward; the hyaline lips rather coarse and prominent; the outer subterminal wall-cell growing out to form a variably developed and outcurved, deeply suffused appendage, sublateral on the right side. Spores about 36 × 2.5 μ. Perithecia 45–50 × 18 μ, the neck 35 × 12 μ. Cell *i* 5.5 × 9 μ. Total length to tip of perithecium 80–100 × 23–27 μ.

On *Laccophilus* sp., near the middle of the outer margin of the right elytron. Grand Etang, Grenada, No. 2687: and Sangre Grande, Trinidad, No. 2684, B. W. I.

This species is more nearly allied to *C. Grenadae* and *C. rhynchostoma*, from which it is at once distinguished by the position of its helicoid appendage on the right side, by the neck-like, incurved tip of its perithecium, subtended externally by a dark out-curved appendage from the wall-cell.

CHITONOMYCES UNCINULATUS Thaxter. Plate XII, figs. 313–314.

L. c. 52, 8.

Uniform pale dirty yellowish brown, evenly curved throughout, or almost crescent-shaped. Basal cell sometimes twice as long as broad, rather stout and straight, tapering below; cell *b* somewhat flattened and distinguished by slight constrictions above and below; cells *c*, *d*, *e* subequal, well developed, normal; cell *f* very long and narrow, distally somewhat broader and very slightly intruded between cells *g* and *h;* cell *g* extending free some distance above the apex of cell *h*, and curved strongly inward, so that cell *i*, which is symmetrical, longer than broad and slightly tapering distally, is pushed partly across the base of the tip of the perithecium. Perithecium relatively large and long, distally narrow, and tapering rather evenly to the blunt apex; the outer margin of the venter slightly depressed: a rather long, slender, straight or curved, distally abruptly helicoid appendage diverges from a point close beside the apex of cell *h*, outward across the distal half of cell *g*. Spores about 35 × 2 μ. Peritheeia 72 × 18 μ; its appendage 24–30 × 3.5 μ. Total length to tip of perithecium 100–120 × 27 μ.

On the margin of the right elytron of *Laccophilus* sp., near the middle. Sangre Grande, Trinidad, B. W. I.

A species allied to *C. Grenadae, C. cerviculatus* and *C. rhynchostoma*, all of which grow in very similar positions on the right elytron. It is easily distinguished by the form of its perithecium, and its rather slender, stiff perithecial outgrowth, which is helicoid only at the tip.

Chitonomyces uncigerus Thaxter.

Monograph, Part I, p. 288, Plate XXVI, figs. 27–28. *Heimatomyces uncigerus* Thaxter, l. c. **30**, 478.

This species has been found on Laccophili in the vicinity of New Haven, Connecticut, and at Eustis, Florida; and has also been obtained from specimens of Laccophilus received from Professors Tsou and Gist Gee, collected in China, the latter apparently quite typical. It is found on the posterior legs of its host, and is somewhat similar in general appearance to *C. uncinulatus;* from which it is at once distinguished by its short, compressed tip, bent abruptly outward, or a little to the right, and by the position of its perithecial spine or appendage which, although somewhat similar in form, arises almost from the middle of the right face of the perithecium, somewhat lower than the apex of cell *h*.

Chitonomyces oedipus Thaxter. Plate XII, figs. 315–316.

L. c. **52**, 6.

Short and stout, more or less uniformly and rather deeply tinged with dull brown. Basal cell greatly inflated below, its outline here somewhat like that of a human ear, convex below, its axis horizontal, bearing the foot on its flat upper margin, near one side of which the short distal portion of the cell, narrow below and abruptly broader above, arises; cell *b* small, somewhat irregular, flattened, protruding anteriorly to form a pointed, tooth-like projection, of a longer protrusion, which may extend outward or downward beside the distal end of the basal cell; cells *c, d, e* small, flattened, misplaced and confused; cell *f* narrowing below to its oblique base, the margin evenly convex, distally somewhat overlapped by cell *g*, which is obliquely separated from cell *i;* the latter longer than broad, subsymmetrical, turned abruptly inward beside the tip of the perithecium, horizontal or nearly so. Perithecium relatively large and stout; the outer margin nearly straight above a variably developed rounded projection near its base; the short, abruptly distinguished tip bent to the right, then outward; subtended and exceeded anteriorly by an erect, blunt, slightly tapering upgrowth from one of the wall-cells: a long, straight, curved or subsigmoid tapering outgrowth, which extends some distance above the tip of the perithecium, arising near the apex of cell *h*, projects outward across cells *g* and *i*, bending abruptly upward. Spores 40 × 4 μ. Perithecia 72 × 30 μ; the outer spine 21–26 μ; the inner 45–55 μ. Inflated part of basal cell 36 × 23 μ. Total length to tip of perithecium 100–120 × 35 μ.

On *Laccophilus* sp., growing singly between the terminal claws of the posterior legs: Grand Etang, Grenada, No. 2687, and Sangre Grande, Trinidad, No. 2684, B. W. I.

The inner appendage of this very distinct species arises in a position similar to that of the curled appendage of *C. rhynchostoma*, and its allies; but seems to be of a distinctly different nature. Its swollen basal cell no doubt acts as a buffer, and its restricted position of growth is quite remarkable. It is perhaps more nearly related to *C. orientalis*, and *C. uncigerus*.

Chitonomyces aculeiferus Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires **26**, 44, fig. 9.

As represented by Spegazzini, who found it on the legs of *Laccophilus virescens* in the Lago de Tarzo, Venice, Italy, this species is distinguished by its short, stout, almost long-oval form, its

short, pointed, incurved tip, from the inner side of which a slender, flexed, slightly divergent appendage arises, which is half as long as the perithecium, and extends some distance beyond the tip. It is said to be allied to *C. italicus*.

Chitonomyces distortus Thaxter.

Monograph, Part I, p. 287, Plate XXVI, figs. 29–30. *Hcimatomyces distortus* Thaxter, l. c. **30**, 477.

The types of this species were found on *Laccophilus maculosus* in the vicinity of New Haven, Connecticut, and it has also been found at Cocoanut Grove and Eustis, Florida, as well as at the Grand Etang, Grenada, B. W. I. It occurs on the tips of the anterior legs of its hosts, and is distinguished by the pointed cylindrical prolongation of its tip, which projects sometimes even at right angles, backward away from the primary appendage, and is subtended on the left side by an erect spinous process.

Chitonomyces Bruchi Spegazzini.

L. c. **29**, 480, fig. 22.

This species was found on the margin of the elytra of *Haliplus Bruchi* at Rosario, Argentina, by Spegazzini, and I have seen no specimens. Its characters are not quite clear from his account, cells *a* and *b* being represented as confluent and the receptacle anomalous in other respects. It is clearly recognizable by its short, stout form, pointed almost flat-conical tip and the long tapering pointed appendage which projects inward and upward from the inner distal wall-cell.

Chitonomyces orientalis nov. sp. Plate XI, figs. 289–290.

Pale yellowish, rather stout, somewhat evenly curved throughout. Basal cell even, twice as long as broad; cell *b* well defined, broader than long; cells *c–c* clearly defined, cell *c* larger, triangular in outline; cell *f* about twice as long as cell *g;* cell *i* rather short and broad, subsymmetrical. Perithecium but slightly narrower distally, about one third free; the tip bent abruptly sidewise to the right, irregular, subtended by a small rounded elevation externally, and by one or two elevations on the inner side, the lower larger; one of the wall-cells on the left side, opposite to and close beside the insertion of cell *i*, growing upward to form an erect, subsigmoid, tapering, brownish appendage which, when mature, may be half as long as the perithecium, or even more; but is more often present as an erect, tooth-like projection, hardly exceeding the apex of the perithecium. Perithecium 80–85 × 25 μ; fully developed appendage 50–58 × 9 μ at base; from point of origin 64–70 μ. Cells *a–e*, including foot, about 60 μ. Total length to tip of perithecium 125–135 × 35–38 μ; to tip of appendage 170–175 μ.

Near the tip of the posterior legs of *Laccophilus* sp., Nos. 3161 and 3162, China (Professor Tsou comm.).

Only two, among a dozen specimens examined, show the fully developed appendage as above described, which recalls that of *C. Bruchi* Speg., although relatively shorter. In these it extends free some distance above the tip of the perithecium, and the attenuated apex is more or less recurved. In the remaining individuals, two of which belong to the same spore-pair, figure 290, at right, the process may not reach the apex of the perithecium, and is short, straight and erect. Cell *i* may be nearly erect or rather strongly bent inward.

Chitonomyces spinigerus Thaxter.

Monograph, Part I, p. 288, Plate VIII, figs. 15–16. *Heimatomyces spinigerus* Thaxter, l. c. **30,** 478.

This species has been found but once, on the posterior leg of *Laccophilus maculosus* near New Haven, Connecticut. It is well distinguished by its perithecium, which is almost wholly united to the receptacle, below its very short, outcurved apex, and bears a somewhat variably developed, spine- or tooth-like outgrowth, which projects externally, near its base. It is most nearly allied to the following species.

Chitonomyces ensiferus Spegazzini.

L. c. **27,** 45.

Found by Spegazzini on *Laccophilus virescens* at Conegliano, Italy, on the abdomen and the margin of the elytra, and apparently well distinguished from *C. spinigerus,* to which it is most nearly allied, from the fact that the perithecium appears to be nearly one half free, and that its appendage arises somewhat higher on the anterior side, and is more erect.

Chitonomyces dentiferus Thaxter.

Monograph, Part II, p. 264, Plate XXXIV, figs. 26–27. *Heimatomyces dentiferus* Thaxter, l. c. **41,** 306.

This species, which was found at Eustis and Daytona, Florida, near the base of the left elytron of *Laccophilus proximus,* along the margin, is most nearly related to *C. appendiculatus,* from which it differs chiefly in the form and character of the erect, tooth-like appendage, or outgrowth, which arises externally below the longer, rather abruptly in- and up-curved tip.

Chitonomyces appendiculatus Thaxter.

Monograph, Part I, p. 287, Plate XXVI, figs. 25–26. *Heimatomyces appendiculatus* Thaxter, l. c. **27,** 31.

This well marked species occurs on the anterior legs of species of *Laccophilus,* and was first found in the vicinity of New Haven, Connecticut. It was also found at Sangre Grande, Trinidad, B. W. I. Though closely allied to *C. dentiferus,* it is clearly distinguished by the form and character of its perithecial appendage, which is straight, subclavate diverging at an angle of about 45°.

Chitonomyces striatus Thaxter. Plate XII, figs. 311–312.

L. c. **52,** 12.

Very small and rather slender. Foot relatively large; basal cell rather uniform, longer than broad, more or less suffused below with blackish brown; cell *b* hardly broader, broader than long, distinguished by slight indentations; cells *c, d, e* normal, subequal; cell *f* relatively short, its rounded extremity obliquely and subsymmetrically separated from cells *g* and *h;* which are nearly equal and as long, or longer, than cell *f;* the region included by cells *g, h* and the upper part of *f,* more or less deeply suffused with clear brown, and crossed, on the right side only, by seven or eight variably distinct blackish lines or ridges, parallel and horizontal, and extending more than half way across the adjacent venter of the perithecium, which is otherwise nearly hyaline: cell *i* erect or bent slightly inward, somewhat longer than broad, suffused below, hyaline above. Perithecium relatively long, narrow and subsigmoid, tapering distally; the strongly convex outer margins slightly undulate; the third external wall-cell producing, from its base, a rather slender, very slightly curved, blunt appendage, which diverges at an angle of 45°, or

somewhat more; the often abrupt distal curvature of the perithecium carrying the usually upcurved, rather slender tip and apex inward and sidewise; the latter ending in a prolongation which forms a rather slender, hook-like upgrowth of the hyaline inner lip-cell, which is more or less recurved above the pore; the whole somewhat hood-like. Spores about 20 × 15 μ. Perithecia 46–50 × 10 μ; the appendage 9–10 × 2–2.5 μ. Total length to tip of perithecium 75–80 × 16–17 μ.

On the upper surface of the prothorax of *Laccophilus* sp., No. 2687, Grand Etang, Grenada, B. W. I.

The position occupied by this species is an unusual one. It is very nearly related to *C. appendiculatus* and *C. dentiferus*, from which it is clearly distinguished by the conformation of its apex and the peculiar transverse lines and suffusion on the right side.

Chitonomyces lichanophorus Thaxter.

Monograph, Part I, p. 290, Plate XXVI, figs. 15–16. *Heimatomyces lichanophorus* Thaxter, l. c. **27**, 32.

The types of this species were found on the median inferior anal appendages of *Laccophilus maculosus* in the vicinity of New Haven Connecticut, and it was again found on *Laccophilus* sp. at Eustis and Daytona, Florida. It is a very characteristic species, well distinguished by its abnormally large and blackened basal cell, and the modification of cells *g* and *i* to form an erect, cylindrical pseudo-appendage, which extends far above the tip of the perithecium.

Chitonomyces elongatus Spegazzini (*nec* Thaxter).

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **27**, 45, fig. 10.

This peculiar form, discovered by Spegazzini on a species of *Laccophilus* in the Lago de Tarzo, Venice, Italy, resembles the preceding species in the anomalous development of cells *g* and *i*, or rather of cell *g* in particular. It is further characterized by a very slender and long basal cell, which is curled upon itself and is unlike that of any other species. It grows between the anterior legs on the inferior surface of the thorax.

Chitonomyces corniculatus nov. sp. Plate XI, figs. 287–288.

Pale straw-yellow, straight or rather evenly and slightly curved. Cell *a* twice or more than twice as long as broad, somewhat broader distally; cell *b* broader than long; cells *d–e* obliquely related, large; cell *d* lying wholly below cell *c*, which is much smaller; cells *f*, *g*, *i* subequal in length; cell *i* erect, subsymmetrical, free. Perithecium relatively very long, almost wholly free, of nearly uniform diameter throughout, slightly twisted, so that the pore is lateral; the tip blackened, tapering rather abruptly from a broad base, its inner margin convex and including the pore; the outer margin convex, the whole terminated by an erect, subsigmoid, partly translucent, blunt-tipped, horn-like prolongation; the whole subtended, on the opposite side, by a short, broad, rounded, somewhat obliquely divergent prominence formed by a single wall-cell. Perithecium 150–175 × 28–30 μ, the black termination and its prolongation 38–42 μ. Cell *a* about 42 × 17 μ distally; cells *f–i* 64 × 13 μ. Total length to tip of perithecium 250–270 × 28–30 μ; to tip of cell *i* 125–140 μ.

Near the tip of the right leg of *Laccophilus* sp., No. 3160. Soochow, China, Professor Gist Gee.

This large and striking species is most nearly related to *C. psittacopsis*, which grows in a similar position, but is clearly distinguished by the wholly different conformation of the tip of

the perithecium. Owing to a slight twist in the latter, the distal portion of the receptacle is not visible when the tip is seen sidewise, figure 288.

Chitonomyces Bullardi Thaxter.

L. c. **37,** 31. Monograph, Part II, p. 265, Plate XXXIV, figs. 32–35.

This is one of the most peculiar species of the genus and was discovered by Mr. Charles Bullard in the vicinity of Cambridge, on the inferior anterior right margin of the prothorax of *Cnemidotus 12-punctatus*. It is abundantly distinguished by its monstrously developed basal cell, and the relation of the latter to the perithecium, which terminates in a black apex, resembling a parrot's beak, not unlike that of the following species to which, however, it is not nearly related.

Chitonomyces psittacopsis Thaxter.

L. c. **37,** 30. Monograph, Part II, p. 266, Plate XXXIV, figs. 23–25.

This large and slender species was first found at Eustis Florida on *Laccophilus proximus*, and has since been obtained on *Laccophilus* sp. at the Grand Etang, Grenada, and at Sangre Grande, Trinidad, on a species of the same genus. It grows in clusters on the posterior legs, and is well distinguished by its long slender habit, large size, and by its conspicuous black tip, shaped like a parrot's beak, and contrasting with the otherwise quite hyaline perithecium and receptacle. It is here associated with *C. Bullardi* on account of the similarity of the tip in either case, but the two are not related.

Chitonomyces longirostratus Thaxter. Plate XII, figs. 324–325.

L. c. **52,** 14.

Pale straw-yellow. Foot small; basal cell more or less often greatly elongated, becoming opaque; cell *b* squarish, or slightly longer than broad; cells *c* and *e* small, and lying wholly above the much larger cell *d*, which is slightly intruded between them; cell *f* long and narrow, hardly overlapped by cell *g;* cell *i* hyaline, four times longer than broad, rather uniform, the apex slightly asymmetrical. Perithecium subclavate, or somewhat broadened distally, curved sidewise, united to the receptacle below the enormously elongated tip; which is abruptly distinguished, of nearly uniform diameter throughout; the lower, inner half opaque, the other translucent purplish brown, straight and rigid; the apex short, hyaline, slightly oblique, the upper lip prominent. Spores about 30 × 2 μ. Perithecia: body 65–78 × 18–20 μ, the tip 245–260 × 8–11 μ. Total length to base of tip 140–156 μ.

On the outer margin near the tip of the right elytron of *Laccophilus* sp., Sangre Grande, Trinidad, B. W. I.

The extraordinarily elongated tip of this species, which probably acts as a "trigger organ" distinguishes it from all others except the following, which may be merely a variety. The receptacle and the body of the perithecium are so flexed, that the tip projects sidewise at an angle of 45° or more, and the former are turned edgewise in preparations of mature individuals. It is only in undeveloped specimens that, as in figure 325, the normal cell-relations can be made out.

Chitonomyces argentinensis Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29,** 479, fig. 21.

This species is said to occur on the posterior margin of the elytra of *Canthydrus debilis*, in La Plata, Argentina. Although it is somewhat smaller, the total length being but 250 μ, and

the tip is relatively shorter and more blunt, as represented in the figure, it seems too near the preceding species and may prove only a variety. I have seen no specimen of this or of others of Spegazzini's species.

Chitonomyces prolongatus nov. sp. Plate XI, fig. 302.

Somewhat curved or subsigmoid, tapering above and below. Cell *a* tinged with brown, the posterior margin deeper, but slightly broader distally, slightly longer than broad; cell *b* somewhat flattened; cell *c* larger than cell *d;* cell *e* much smaller; cell *f* very narrow, its axis coincident with that of the shorter cell *h;* both somewhat suffused with brown and overlapped by cell *g*, which is blackened, and extends down beside them to cell *e*, its outer margin convex, more so distally; cell *i* somewhat convergent, nearly symmetrical, about twice as long as broad, forming with cell *g*, a continuous posterior blackish margin, the insertion of the appendage terminal. Perithecium about one half free, hyaline, its venter narrow and straight; the tip abruptly distinguished, slightly bent outward and curved, tapering to a rather sharp apex, and slightly more than one third as long as the body; its inner margin, especially below, variably suffused with brown. Body of perithecium 60–68 × 12–16 μ; the tip about 25 × 8 μ. Cells *a* to *e*, including foot, 42 × 14 μ. Blackened area of margin 58–64 μ. Total length to tip of perithecium 125–140 × 26 μ.

On the margin of the left elytron of a species of *Laccophilus* sp. received from Professor C. V. Piper, Puyallup, Washington.

This species is most nearly allied to *C. marginatus*, which accompanied it, and *C. seticolus*, from both of which it is readily separated by the pointed prolongation of its tip, and the fact that cell *i*, although suffused, is otherwise unmodified and nearly symmetrical.

Chitonomyces marginatus Thaxter.

Monograph, Part I, p. 289, Plate VIII, figs. 25–28. *Heimatomyces marginatus* Thaxter, l. c. **27**, 34.

This form is a straight and rather slender type, in which the body of the perithecium is hyaline and wholly united to the distal part of the receptacle, below the short, abruptly distinguished, distally somewhat inflated and incurved tip and apex. In the distal part of the receptacle, cell *g* overlaps cell *f* to its very base, so that they lie parallel, side by side; and, owing to a common almost opaque suffusion, are mostly indistinguishable. Cell *h* is narrow, quite half as long as cell *f*, and remains hyaline; although it is usually hidden by the adjacent suffusions. Cell *i* is similarly suffused, erect, producing distally an erect, slightly narrower, distally broader and truncate upgrowth, nearly as long, and separated from it by a hyaline line; the insertion of the filamentous part of the appendage pushed to a lateral position on the inner side, subtending the projection.

The types of this species were collected in the vicinity of New Haven, Connecticut, and it has been found at Kittery Point, Maine, and on Laccophili received from Professor Barber from Lawrence, Kansas, Professor Piper from Puyallup, Washington and also from Jamaica, W. I. It always grows slightly within the margin of the left elytron, near the tip; although, in one instance, it was found on the posterior legs. It is closely allied to the preceding and following species, especially to the latter.

Chitonomyces seticolus Thaxter, Plate XII, figs. 305–307.

L. c. **52**, 11.

Nearly hyaline, becoming pale yellowish: form slender, slightly sigmoid. Cell *a* rather uniform, somewhat longer than broad; cell *b* somewhat flattened, distinguished above and below

by slight constrictions; cells *c*, *d*, *e* subequal, well defined, subtriangular; cell *e* very obliquely separated from cell *f* and the base of cell *g*, which extends even below that of cell *f;* the two lying parallel, the former much thicker, suffused with blackish brown, more often concealing the latter, which remains hyaline, and is very narrow, like cell *h*, which may be more than half as long; cell *g* showing coarse transverse mottlings or ridges on the margin and right side, seven or eight in number, often obscured by the depth of the suffusion; cell *i* nearly twice as long as broad, similarly suffused, though slightly translucent; straight, somewhat overlapping the tip of the perithecium, and producing a terminal upgrowth; which is somewhat narrower, half as long or less, distally somewhat pointed or hooked, separated by a hyaline line, below which on the inner side, after a short interval, is placed the base of the filamentous appendage: the whole suffused portion forming an evenly convex black margin, opposite the perithecium. Perithecium rather narrow, slightly concave near the base, externally; the short tip abruptly narrower, the somewhat irregular and swollen apex turned outward.

Growing among the bristles, just within the margin of the left elytron of *Laccophilus* sp., Grand Etang, Grenada, B. W. I.

This species is very closely allied to *C. marginatus*, a few individuals of which were found in the same locality and on the same host, growing in its usual position on the margin of the elytron, slightly nearer the base. The original description of this form appears to have been erroneous in several respects, as has been shown by a reexamination of material which has lain for some years in glycerine, and has become more translucent and thoroughly turgescent. Cell *f* in some individuals can be seen to be hyaline, and cell *g* appears to overlap it lengthwise in such a way that it can be seen only in certain cases. The accompanying figures 306 and 307 also give an erroneous idea of the position of the transverse ridges, which occur only on the right side and are here represented on the left side, showing through from the right. The most evident character which separates it from *C. marginatus* is that of cell *i*, which is relatively twice as long, its upgrowth half as long, and very differently shaped; tapering characteristically, instead of ending in a broad, truncate expansion.

Chitonomyces bicolor Thaxter. Plate XII, figs. 303–304.

L. c. **52**, 11.

Hyaline, or becoming faintly tinged with dirty yellowish brown. Basal cell two or three times longer than broad, tapering slightly below; cell *b* much flattened, horizontal; cells *c*, *d*, *e* subequal, relatively large, subtriangular, typical; cell *f* long and narrow obliquely separated from cell *e;* but slightly overlapped by cell *g* which is about as long as cell *h;* its outer margin slightly divergent, distally slightly prominent below the base of cell *i*, which extends to, or slightly above, the tip of the perithecium, erect, blackish brown, somewhat translucent, opaque externally and distally, abruptly and more or less strongly curved outward distally, where its convex margin is roughened or coarsely tuberculate. Perithecium erect, about one-third free, the outer margin often convex below, tapering, somewhat distally, to the broadly spreading asymmetrical termination, which is outwardly rounded and prominent, sometimes slightly suffused, a much more prominent free rounded projection directed inward, and often wholly or partly overlapping cell *i;* a slight, median, papillate projection also arises near the pore. Spores about 24 × 2 μ. Perithecia 60–80 × 12–14 μ. Cell *i* about 30 × 7 μ. Total length to tip of perithecium 100–125 μ.

On the outer margin of the left elytron of *Laccophilus* sp., No. 2684, Sangre Grande, Trinidad, and on the same species, No. 2687, Grand Etang, Grenada, B. W. I.

This species is allied to *C. javanicus* on the one hand, and to *D. seticolus* on the other: cell *i* alone, however, being suffused and distally proliferous. The distal curvature of this cell, and the prominence of its tuberculate elevations, vary considerably; but the form is well marked, and easily distinguished from similar types.

Chitonomyces javanicus Thaxter.

L. c. **41**, 307. Monograph II, p. 266, Plate XLII, figs. 37–38.

This species was found on the margin of the left elytron of a Javan *Laccophilus*, and is another example which illustrates the abnormal development of cell *i*, similar to that in *C. marginatus* and *C. bicolor;* a development associated with deep suffusion which, in the present instance, involves also cell *g*, the two forming a continuous, blackened, slightly curved, subclavate and pointed pseudo-appendage extending considerably above the tip of the perithecium; which is broad and subtended externally by a short, somewhat suffused upgrowth, very similar to that of *C. melanurus*, to which it is more nearly allied.

Chitonomyces helicophorus Thaxter. Plate XI, figs. 297–298.

L. c. **52**, 10.

Color clear pale straw-yellow; the axis nearly straight. Basal cell hardly twice as long as broad, slightly narrower below and broader at its junction with cell *b*, which is but slightly shorter; the region of cells *c–e* abruptly slightly broader than cell *b;* cell *d* relatively long, its base occupying the whole upper margin of cell *b;* cells *c* and *e* similar, but slightly smaller; cell *f* more than twice as long as cell *g*, which overlaps it slightly, and is narrower than the somewhat shorter cell *h*, and distally slightly suffused, the base of cell *i* bulging prominently just above this suffusion; and prolonged for twice its length above the insertion of the filamentous appendage, which is turned so as to occupy a lateral position on the inner side, the proliferation curved outward, and distally strongly helicoid, the convex margin distinguished by a broad purplish brown suffusion extending nearly to its curled pointed apex; the cell proper and the outer, concave, margin hyaline, or nearly so. Perithecium narrower below, its outer margin evenly convex, the flaring tip abruptly distinguished by an erect, reddish brown, finger-like projection, appressed and extending to the small, hyaline, blunt apex, which it partly conceals; the inner subterminal wall-cell broadly subtriangular, flat; projecting on the inner side to form a divergent, bluntly subconical process, the lower margin of which lies close beside the lower two-thirds of cell *i* and its proliferation. Spores about $25 \times 2\ \mu$. Perithecia $54–60 \times 12.6\ \mu$; the anterior projection $14 \times 5\ \mu$; $18\ \mu$ by $18\ \mu$ at the base. Total length to tip of perithecium $100 \times 19\ \mu$.

Near the middle of the outer margin of the left elytron of *Laccophilus* sp., No. 2680, Sangre Grande, Trinidad, B. W. I.

This species is very closely allied to *C. melanurus*, the tip of the perithecium being similar, except in details of conformation. Cells *g* and *i* are, however, hyaline; and the latter, with its prolongation, differently shaped. It is a very beautiful and well defined variation among the five species of this general type.

Chitonomyces japanensis nov. sp. Plate XII, figs 308–309.

Similar to *C. melanurus*, somewhat more slender, similar in color. Apex of the perithecium but slightly spreading, the outer lip-cell small, protruding slightly, overarching the pore; which is subtended below, on the inner side, by a short, blunt projection from the inner lip-cell; the external subtending appendage erect, long, slender; its distal half curved strongly outward.

tapering to a blunt apex; its base rather abruptly and evenly convex. Perithecium about one third free, 70–85 × 12–16 μ, the external appendage 40–46 × 5 μ. Cells *g* and *i*, and the extension of the latter, 45–55 μ. Total length to tip of perithecium 120–135 μ.

On the margin of the left elytron of *Laccophilus* sp., No. 2940, Okayama, Japan, Professor H. H. Chung.

A group of fourteen individuals of this form was found on a species of *Laccophilus* very kindly given me by Mr. Chung, and on the same individual, in a slightly different position, was also growing a group of *C. melanurus*, the characters of which were quite typical. It was at first thought that the present species might be merely a variety; but as the individuals of the two groups show no tendency to vary toward one another, and as this is the case with other examples of *C. melanurus* from the orient, it seems unlikely that they should prove the same. The long slender tapering outcurved external perithecial appendage is quite unlike that of *C. melanurus*, and the characteristic conformation at the apex is distinctly different.

Chitonomyces chinensis nov. sp. Plate XI, fig. 286.

Relatively large, rather dirty yellow; the base, cells *a–b*, abruptly bent at an angle of about 45° to the axis of the portion above, which is more than twice as long. Cell *a* narrow below and often bent; its extremity abruptly much broader; its anterior margin concave, blackened, more broadly distally, the posterior convex below, and slightly concave above, somewhat obliquely separated from cell *b;* which is much flattened, the posterior side larger; cells *c–e* somewhat irregularly associated, subequal; cell *c* overlapping cell *d* on the right side, its extremity usually protruding to form a more or less distinct elevation on the right side; cells *d* and *e* subtriangular and subequal; cell *f* relatively long, broader distally, its outer margin somewhat concave, especially below; cell *g* relatively short, subtriangular, distally conspicuously prominent, the short and broad subsymmetrical cell *i* directed inward and overlapping the tip of the perithecium. Outer margin of the perithecium rather evenly convex, distally abruptly so, as it passes into a deep brown, incurved, stout, horn-like outgrowth of the outer subterminal wall-cell, the blunt free extremity of which extends at right angles over and beyond the pore, and beyond the line of the distal outer margin of the receptacle, the region around the pore forming a rounded vesicular prominence, lying at the base of the concavity formed by the terminal horn and the protrusion of cell *g*. Perithecium, below the tip, almost wholly united to the receptacle; not including horn, 100–130 × 28–32 μ: terminal horn, measured transversely, 45–50 μ. Cells *f* and *g* 100–125 μ; cell *i* 15 × 13 μ, cell *a* 65–75 × 32 μ. Total length 190–230 μ.

Along the margin of the distal half of the right elytron of *Laccophilus* sp., No. 361, China, Professor Tsou: No. 3161, Soochow, China, Professor Gist Gee.

A fine species, not nearly allied to any of the known forms; distinguished by its large size, geniculate base and large overarching terminal perithecial horn-like outgrowth.

Chitonomyces melanurus Peyritsch. Plate XII, fig. 310.

Sitz. d. k. k. Acad. Wiss. Wien, **67,** 251, Plate III, figs. 30–34. Thaxter, Monograph, Part I, p. 289, Plate XXVI, fig. 19. Spegazzini, Ann. d. Mus. Nac. d. Hist. Nat. **27,** 47, fig. 13.

This species, which is the type of the genus, has been reported from various European states, and from northern Africa, inhabiting the margin of the left elytron of various species of *Laccophilus*. Specimens corresponding exactly to the European type have also been found on similar hosts received from Professor Tsou and collected in China; also from Professor Gist Gee, Soochow, and from Mr. Chung, Okayama, Japan. With *C. bicolor*, *C. javanicus*, *C. helicophorus* and *C. japanensis*, it forms a well defined group, closely related to that of *C. marginatus*,

all characterized by peculiar modification of the distal cells of the receptacle, variably associated with conspicuous suffusions.

Chitonomyces paradoxus (Peyritsch) Thaxter.

L. c. **27**, 32. Monograph, Part I, p. 287, Plate VIII, figs. 17–21. *Heimatomyces paradoxus* Peyritsch, Sitz. d. k. k. Acad. Wiss. Wien, **67**, 251. Plate III, figs. 35–39.

This very distinct and remarkable type includes various striking variations, which I have felt unwilling, for the most part, to segregate. These include differences in general form; whether short and stout, or long and rather slender; in the conformation of the peculiar outgrowths in the region of cell *h* on the left side, and the form, relative size and relation of the horn-like distally projecting wall-cell of the perithecium; in the relation of this horn and the apex of the perithecium to cell *i*, and the cells immediately below it, whether closely appressed or widely separated; in the subsigmoid or nearly straight outer margin from base to apex; in the variations in coloration, whether pale or dark, uniform or otherwise, and in other points of minor importance. The variety, for example, figured in Part II of my Monograph, Plate XLII, figure 39, which occurs in Java, growing in the usual position on the extreme edge of the margin of the left elytron, near the tip, is a comparatively slender type, nearly straight, pale; cells *g* and *i* slightly convergent and close to the adjacent margin of the perithecium, the horn-like outgrowth from which is terminal and erect, narrow, tapering and nearly as long as the perithecium as a whole; the subtending wall-cell comparatively small and not at all prominent. In a variation from China, on the other hand, the general anterior margin is strongly subsigmoid; the habit short and stout; the distal part of the perithecium strongly convex on the inner margin, and separated from the divergent projection formed by cells *g* and *i* by a wide depression: while the relatively short and stout outcurved perithecial horn is subtended by the relatively very large and conspicuously prominent subtending wall-cell, which may almost equal it in size; the rounded apex-region protruding inward abruptly; while, in the Javan form, it forms a small and relatively inconspicuous elevation on the otherwise straight margin. From the West Indies several variations have been obtained. One of these, for example, is characterized by a partly or wholly blackened basal cell, and a short, stout, blunt, erect terminal horn, the subtending wall-cell inconspicuous; while cells *g* and *i* are abruptly convergent, and partly overlap the adjacent upper half of the perithecium; in marked contrast to the condition just described in the material from China. Since more or less intermediate variations also occur, I have thought it inadvisable to segregate these variations, even as varieties. In one case, however, it has seemed best to give a new specific name to an extreme variant, collected several times at the Aripo Savanna in Trinidad, which, in addition to its unusual conformation in other respects, is unlike any other form in producing a conspicuous rounded outgrowth from one of the perithecial wall-cells, on the right side. A second form has also been separated by Spegazzini in which the horn is hardly at all developed. The species always occurs on Laccophili near the margin of the left elytron.

The typical condition is now known from several regions in this country; New England, Kansas, Florida, Jamaica, W. I., and various parts of Europe, as well as from Sumatra. In all the variations of this species, including the two forms distinguished below, the ascogenic cell occupies an unusual position, opposite the distal end of cell *f*, the asci growing downward, outward and upward in a very characteristic fashion, found, I believe, in no other species. The variant separated by Spegazzini, and that from the Aripo Savanna, are distinguished as follows.

Chitonomyces truncatus Spegazzini.

Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **27**, 47, fig. 14.

The general form of this species is represented as very short and stout, the termination of the perithecium very broad, flat and more or less distinctly three-lobed; the outer lobe corresponding to the terminal horn of *C. paradoxus*, but short and distally flattened. Cells *g* and *i* are short, stout and divergent from the opposite concave inner margin of the perithecium, the outer margin of which is evenly concave. The characteristic outgrowth in the region of cell *h* is said to become black with age. The total length is given as 175–185 μ, which is not unlike that often found in *C. paradoxus*, of which this may prove to be a variety, only.

Chitonomyces aripensis nov. sp. Plate XI, figs. 291–292.

Rather dark yellowish brown. Basal cell large and broad, convex anteriorly, more deeply suffused above the large foot, and along the posterior margin; cell *b* greatly flattened; cells *c*, *d* and *e* small and sometimes hardly distinguishable; cell *f* narrow below, broader distally, where it is obliquely separated from cell *h;* cell *i* slightly more than twice as long as broad, and somewhat divergent. Perithecium about two-thirds free, stout and rather short, broad throughout, or the distal half, which is free and more strongly divergent, tapering but slightly; a vesicular, or umbonate rounded lateral prominence arising laterally on the right side, just below the middle, and opposite the insertion of cell *i;* the tip surmounted by a flat-conical cell, its apex rounded or papillate, symmetrical or irregular, according to the point of view. Perithecium 84 × 50 μ. Cell *a* 25 × 20–25 μ; cell *i* 22 × 8 μ. Total length to tip of perithecium 120–138 × 38–42 μ.

On the margin of the left elytron, near the tip, of a pale *Laccophilus*, Aripo Savanna, Cumuto, Trinidad, No. 2685.

This species is closely allied to *C. paradoxus* and grows in a similar position. It seems clearly distinguished by its small size, general form, its flat conical, or irregularly flattened, terminal cell; which replaces the horn of *C. paradoxus*, and by the presence of an umbonate projection on the right side of the perithecium; while there is no indication of the usual outgrowths from the left side. The material examined was taken from several individuals of the host, found swimming in shallow pools in the Aripo Savanna.

SPECIES EXCLUDENDAE.

Two aberrant types, *Chitonomyces Orectogyri* and *C. aethiopicus*, on *Orectogyrus* (*Orectochirus*) *specularis*, were provisionally placed by me in this genus, and illustrated in my second Monograph. A careful reexamination of these forms has, however, convinced me that this disposition of them is erroneous, and that they represent an aberrant and simple type among the aquatic species of the genus *Laboulbenia*, to which they should be transferred. The characters of the appendages, of which there are but two in either case, are similar to those of the Peyritschielleae, and one of them is inserted at the apex of cell V, which corresponds in position and appearance to cell *h* of *Chitonomyces*. A comparison with other species on Gyrinidae shows that one or more appendages may appear in this position, and that they may closely resemble, through the presence of a blackened basal septum and a more or less vesicular short hyaline distal portion, the type so characteristic of the Peyritschielleae generally. I have evidently been misled by their character and position, and by the fact that I have regarded the small hyaline portion of the foot as representing a much reduced basal cell. As a matter of fact, the basal and subbasal cells are the two lower, large, obliquely superposed cells represented in the figures, and although no primary or secondary stalk-cell is visible below the perithecium, their presence

could no doubt be determined in younger or fresher material. A further indication that the two should be associated with other aquatic Laboulbeniae, is seen in the black tooth-like appendage at the tip of the perithecium in *C. aethiopicus*, which has an individuality peculiar to similar structures in aquatic forms, and is almost identical with that found in *L. denticulata*. I have no hesitation, therefore, in changing the generic reference of the two forms as follows:

Laboulbenia aethiopica nov. comb.

Chitonomyces aethiopicus Thaxter, l. c. **35**, 430. Monograph, Part II, p. 267. Plate XXXIV, figs. 21–22.

Laboulbenia Orectogyri nov. comb.

Chitonomyces Orectogyri Thaxter, l. c. **37**, 32. Monograph, Part II, p. 266, Plate XXXIV, figs. 19–20.

HYDRAEOMYCES Thaxter.

Monograph, Part I, p. 293.

Type Species *Hydraeomyces Halipli*.

Although the type of this genus has been found at various times since its original publication, no further careful study has been given it, and no additional information is available as to its development and possible sexual characteristics; which remain, like those of *Chitonomyces*, to which, undoubtedly, it is most nearly allied, quite problematical. It differs from *Chitonomyces* in having three or four secondary appendages, instead of one, which are separated from a cell corresponding to cell *f;* and also from the fact that cells *a* and *b* are replaced by three superposed cells. The perithecium also differs in having at least six or seven wall-cells on its anterior side, below the abruptly papillate, variably prominent, very characteristic apex. An additional species has been described by Spegazzini, as indicated below, and two species of a closely allied type have also been published by this author. All the species are parasitic on Haliplidae.

Hydraeomyces Halipli Thaxter.

Monograph, Part I, p. 294, Plate VIII, figs. 22–24, Plate XXVI, figs. 31–33. Spegazzini, Ann. d. Mus. Nac. d. Hist. Nat. d. Buenos Aires, **29**, 552, fig. 96. *Heimatomyces Halipli* Thaxter, l. c. **27**, 32.

This is a common species on *Haliplus* and *Cnemidotus*, occurring in no definite position on the host. It is subject to some variation in color and habit, as well as in size. Specimens have been obtained from several localities in New England, and typical material was also found at Eustis, Florida. It is also reported by Spegazzini on *Haliplus obconicus* from La Plata, Argentina and it has been found on *Haliplus* and *Cnemidotus* received from Professor Gist Gee from Soochow, China; the latter quite indistinguishable from the American material.

Hydraeomyces venetus Spegazzini.

L. c. **28**, 52, fig. 17.

I have been unable to determine from the figure and description of this species, why it should be regarded as specifically different from *H. Halipli*. An examination of the material, however, would no doubt make this clear. On *Haliphus* sp. Italy.

PARHYDRAEOMYCES Spegazzini.

L. c. 28, 70.

This type has been separated from *Hydraeomyces* on account of the presence of four superposed cells above the foot, instead of three. It remains uncertain from the figures and description, whether this is actually an additional cell, or one of the smaller cells above the third cell in *Hydraeomyces*, which has become enlarged and somewhat differently placed. In either case, I should not myself regard such a difference as significant, and should be inclined to refer the species to *Hydraeomyces*.

Parhydraeomyces italicus Spegazzini.

L. c. 70, fig. 35.

This species was found by Spegazzini on *Haliplus striaticollis* at Rome. In general habit it resembles the stouter forms of *H. Halipli*, except for the presence of a fourth superposed cell. The species is also reported from Algeria by Maire (Bull. Soc. d'Hist. Nat. d. l'Afrique d. Nord, 7, 11, 1916) on *Peltodytes conifer*. A variety "*neapolitanus*" is also described by Spegazzini, which is said to be somewhat smaller, the receptacle obconical and the basal cell quite hyaline, and was also found on a species of *Haliplus* at Rome (Spegazzini, l. c., fig. 36).

ADDENDUM

Insert before *Dimorphomyces simplex*, p. 326:

Dimeromyces eleusinus Thaxter. Plate I, figs. 19–21.

On the margin of the abdomen, near the tip, of a host first determined as *Eleusis* (*Isomalus*) sp., but which Mr. Arrow tells me belongs to *Inopeplus*, found among a small lot of beetles kindly sent me by Professor Weston from Los Banos, P. I., No. 3128.

The loss of the MS. for this species was overlooked until after the page proof was corrected; but it is so clearly defined by its falcate perithecia, and characteristic appendages, with abruptly narrowed terminations, that it should be recognized without difficulty from the accompanying figures. It seems most nearly related to *D. decipiens*.

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THAXTER --LABOULBENIACEAE

DESCRIPTIONS OF THE PLATES.

NOTE—The original ink-drawings have been reduced in reproduction from 10½ by 9¼ inches. Except where otherwise stated they were made in Plates I to X with Zeiss objective D, ocular 4: in Plates XI and XII with water immersion and ocular 2. The water immersion indicated is the Leitz No. 10.

DESCRIPTION OF PLATE I.

Polyandromyces coptosomalis Thaxter.

Figs. 1 to 6. Progressive stages in the development of the male. Figs. 1 to 3, water im., oc. 2; figs. 4 to 6 Leitz oil im. $\frac{1}{16}$, oc. 2.

Figs. 7 to 9. Mature female individuals. Figs. 7 and 8, Types from Madagascar; fig. 9, Fiji Islands. Zeiss D, oc. 2.

Figs. 10 to 12. Male and two females of the variety MINOR. Male, Leitz $\frac{1}{16}$ oil im., oc. 2; females, Zeiss D, oc. 2.

Nycteromyces streblidinus Thaxter.

Figs. 13 to 15. Mature female, Zeiss D, oc. 2.: young female; mature male; water im., oc. 2.

Dimorphomyces grenadinus Thaxter.

Figs. 16 and 17. Two mature females seen from opposite sides: water im., oc. 2.
Fig. 18. Male.

Dimorphomyces eleusinus Thaxter.

Figs. 19 and 20. Two mature females in different positions, the second associated with a male.
Fig. 20a. Male individual.
Fig. 21. Primary appendages of male and female: water im., oc. 2.

Dimorphomyces furcatus Thaxter.

Figs. 22 and 23. Two females seen from opposite sides.
Fig. 24. Male: water im., oc. 4.

Dimorphomyces argentinus Spegazzini.

Fig. 25. The type of "*D. Meronerae*" Thaxter.
Fig. 26. Male: water im., oc. 4.

Dimorphomyces verticalis Thaxter.

Figs. 27 to 29. Three mature females.
Fig. 30. Male: water im., oc. 4.

Dimorphomyces brevirostris Thaxter.

Figs. 31 and 32. Two mature females. All the figures are from the Jamaican Types.
Figs. 33 and 34. Two males, one having two antheridia: water im., oc. 4.

DESCRIPTION OF PLATE II.

Dimorphomyces Bledii Thaxter.

Fig. 35. Well developed female; the tip bent backward.
Fig. 36. Male: water im., oc. 4.
Fig. 37. Straight perithecium, detached.

Dimorphomyces ramosus Thaxter.

Fig. 38. Mature female with but few appendages broken. Zeiss A, oc. 4.
Fig. 39. Receptacle of female more highly magnified, showing relations of basal cell, appendages and perithecial stalk.
Fig 40. Male with three antheridia.

Dimorphomyces Pachytelis Thaxter.

Fig. 41. Female individual, the receptacle viewed sidewise.
Fig. 42. Young female, showing earlier relations of basal cell.
Fig. 43. Receptacle of mature female seen sidewise, with origins of perithecium and appendages.
Fig. 44. Male bearing two antheridia: water im., oc. 2.

Dimorphomyces obliqueseptatus Thaxter.

Figs. 45 to 47. Three females.
Fig. 48. Male: water im., oc. 2.

Dimorphomyces clavuliferus Thaxter.

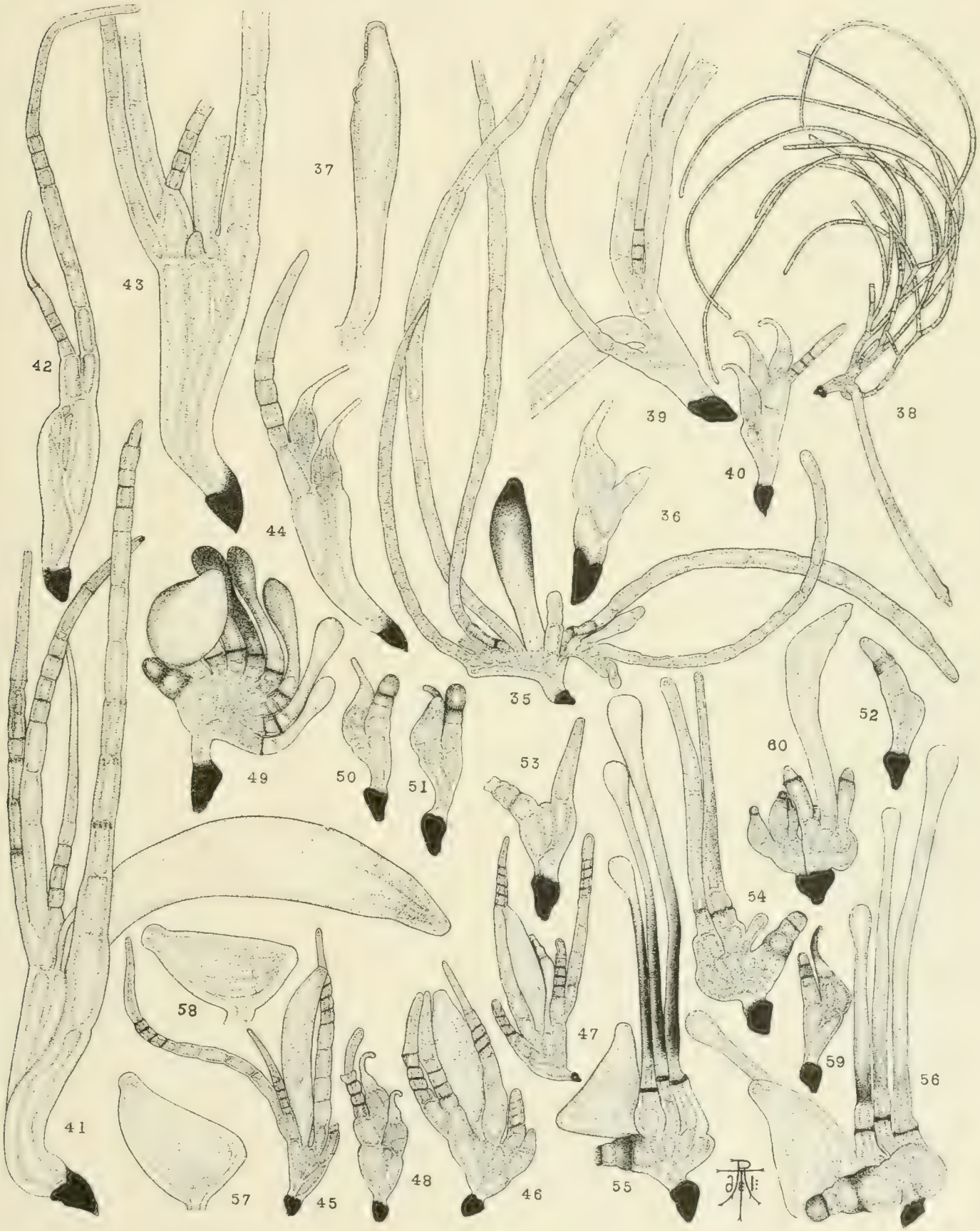
Fig. 49. Mature female: water im., oc. 4.
Figs. 50 and 51. Two males: water im., oc. 4.

Dimorphomyces triangularis Thaxter.

Figs. 52 to 54. Three younger stages in development of female, showing relations of basal cell: water im. oc. 4.
Figs. 55 and 56. Two mature females: water im., oc. 4.
Figs. 57 and 58. Mature perithecia: water im., oc. 4.
Fig. 59. Male individual: water im., oc. 4.

Dimorphomyces simplex Thaxter.

Fig. 60. Male and female from same spore-pair: the necks of the antheridia curved and viewed end-on: water im., oc. 2.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THAXTER.--LABOULBENIACEAE

DESCRIPTION OF PLATE III.

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Fig. 63. Furcate male, the appendage also producing antheridia: water im , oc. 4.

Dimeromyces adventitiosus Thaxter.

Fig. 64. Female individual with two young perithecia developing at right from undifferentiated primary appendage.

Fig. 65. Female individual, showing development of a perithecium near the tip of the primary appendage at left, and from the base of the lower secondary appendage at right. Zeiss A, oc. 4

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Fig. 67. Highly developed male individual, with two secondary appendages; the lower, at left, like the primary, at right, bearing numerous antheridia.

Dimeromyces Peltoidis Thaxter.

Fig. 68. Luxuriantly developed female: the lower secondary appendage at right, developing a perithecium from its basal cell.

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Fig. 71 Male individual: water im., oc. 4.

Dimeromyces brachiatus Thaxter.

Fig. 72. Mature female with three secondary axes, a mature and a young perithecium, and a single secondary appendage; the short primary appendage at the right. Zeiss D, oc. 2.

Fig. 73. Portion of a secondary axis showing appendages and very small lumina: the heterogeneous subulate secondary appendage not yet developed: water im., oc. 4.

Fig. 74. Male individual, the bent neck of the antheridium seen end-on.

Dimeromyces subuliferus Thaxter.

Fig. 75. Young female individual, with trichogyne, showing early displacement of the two lower cells of the receptacle lying obliquely at the left: water im., oc. 4.

Fig. 76. Nearly mature female.

Fig. 77. Fully mature female, with male adherent at the right. Seen from side opposite to that shown in fig. 76.

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DESCRIPTION OF PLATE IV.

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Fig. 81. Young female on *Macrocheles*.

Fig. 82. Spore with very short basal segment: water im., oc. 4.

Fig. 83. Male individual on *Parasitus*.

Dimeromyces Dhanyae Thaxter.

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Dimeromyces amazonicus Thaxter.

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Dimeromyces Heterophylli Thaxter.

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Dimeromyces Cryptici Thaxter.

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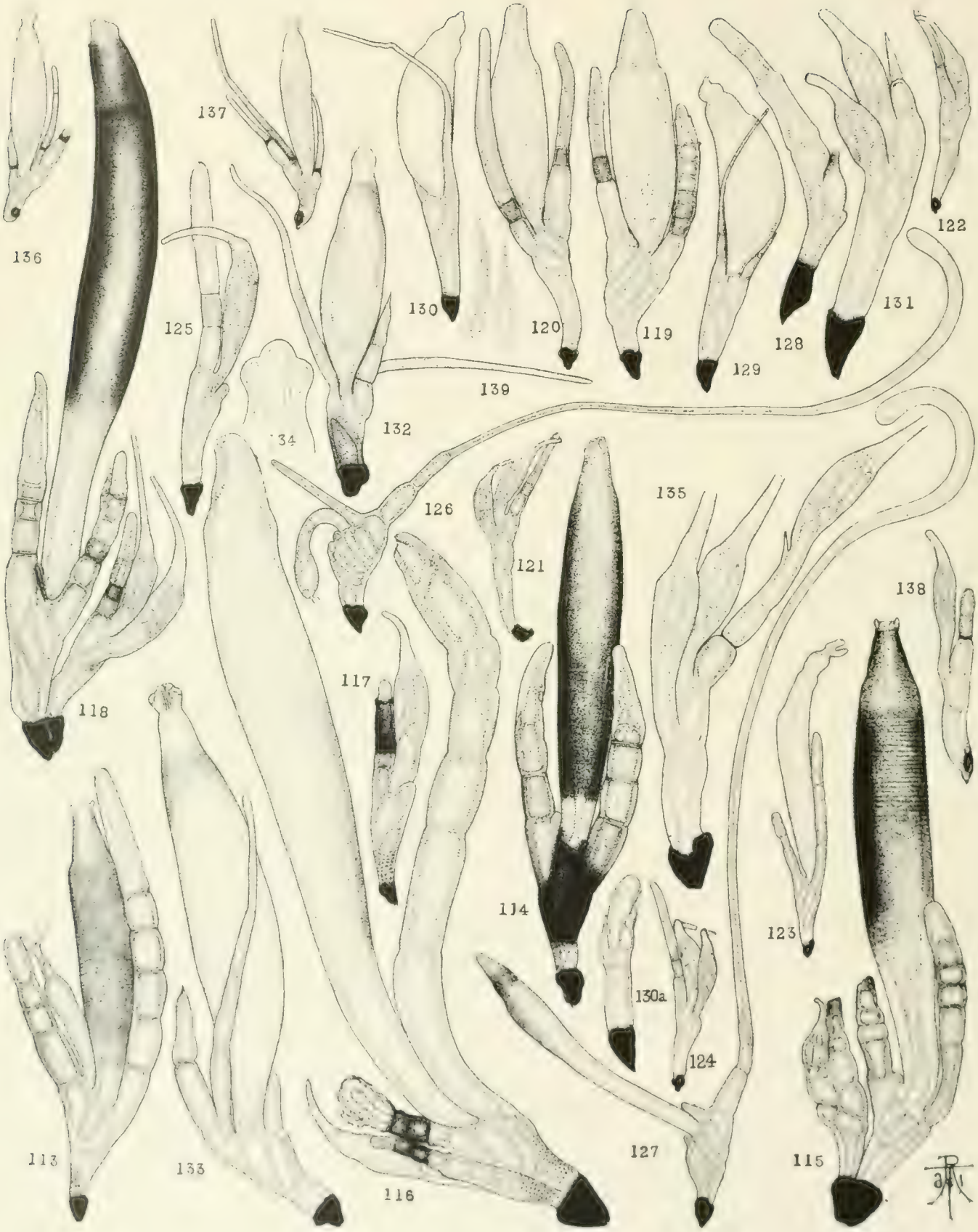
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Dimeromyces decumbens Thaxter.

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Dimeromyces sulcatus Thaxter.

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Dimeromyces Galumnae Thaxter.

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Dimeromyces Homophoetae Thaxter.

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Dimeromyces Hermoeophagae Thaxter.

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Dimeromyces rigidus Thaxter.

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Dimeromyces helicoideus Thaxter.

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Dimeromyces appendiculatus Thaxter.

Figs. 161 and 162. Two females showing variation in appendage.

Fig. 163. Tip of perithecium enlarged: water im., oc. 4.

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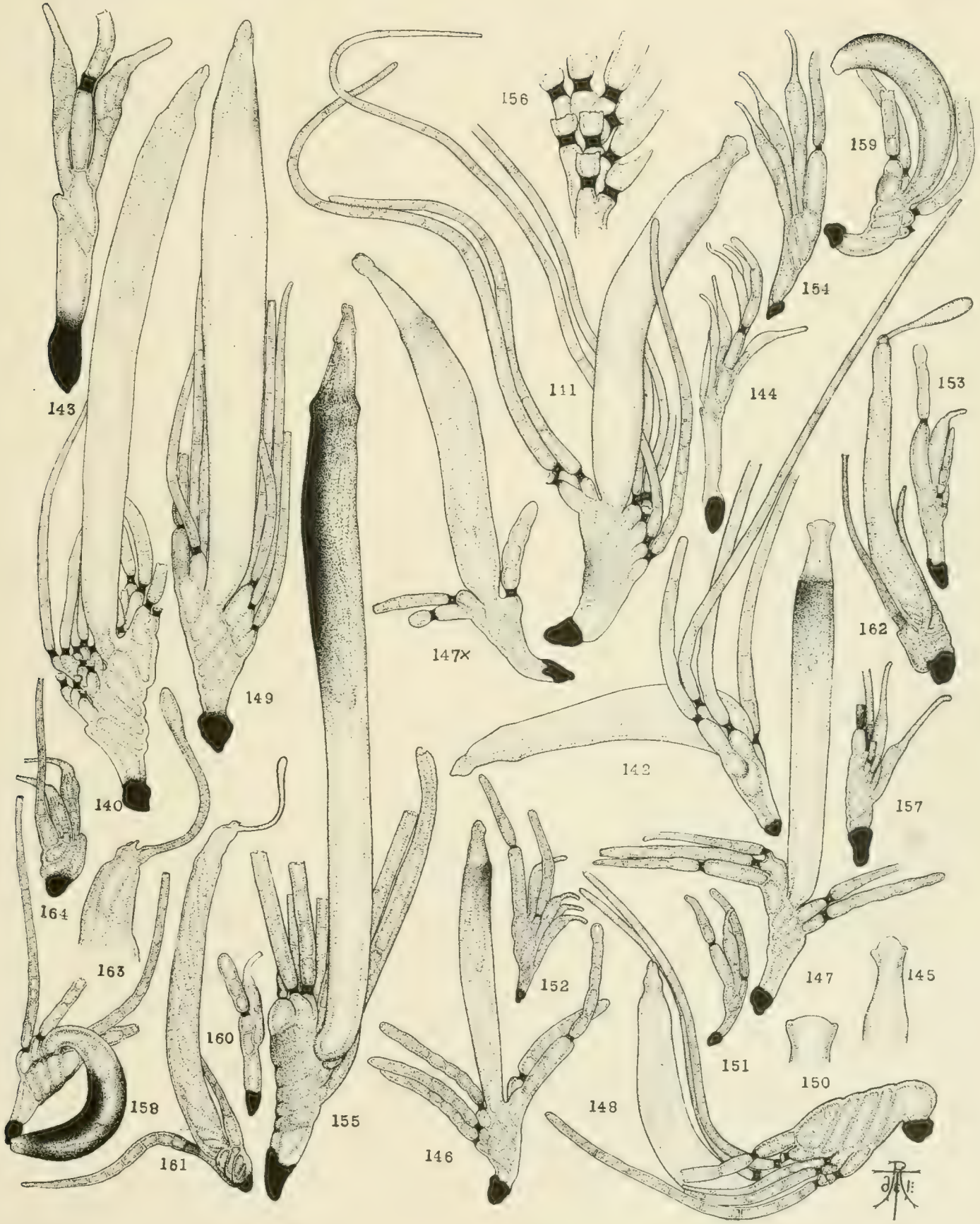

COCKAYNE BOSTON

THAXTER.--LABOULBENIACEAE

DESCRIPTION OF PLATE VIII.

Dimeromyces Gonocnemalis Thaxter.

Fig. 198. Well developed female, two young perithecia with trichogynes.
Fig. 199 and 200. Males, with two and one antheridium.

Dimeromyces Platycillibis Thaxter.

Figs. 201 and 202. Two females, with and without a lower secondary appendage.
Figs. 203 and 204. Two males, the second more highly magnified; water im., oc. 4.

Dimeromyces Tomoderi Thaxter.

Figs. 205 and 206. Two females seen from opposite sides.
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Dimeromyces ametrothecalis Thaxter.

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Fig. 210. Male.

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Dimeromyces Copropori Thaxter.

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Dimorphomyces decipiens Thaxter.

Figs. 214 and 215. Two females seen from opposite sides.
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Figs. 217 and 218. Two females from opposite sides.
Fig. 219. Normal male: water im., oc. 4.
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COCKAYNE BOSTON

THAXTER.--LABOULBENIACEAE

THAXTER.--LABOULBENIACEAE

DESCRIPTION OF PLATE IX.

Dimeromyces moniliformis Thaxter.

Figs. 221 and 222. Two females seen from opposite sides, the first with male.
Fig. 223. Male.

Dimeromyces Chaetospaniae Thaxter.

Figs. 224 and 225. Two females seen from opposite sides.
Figs. 226 and 227. Young females showing cell-relations, with displacement: water im., oc. 4.
Fig. 228. Male individual: water im., oc. 4.

Dimeromyces lobatus Thaxter.

Figs. 229 and 230. Young females, the perithecia immature. Zeiss D, oc. 12 and D, oc. 4 respectively.
Fig. 231. Mature male. Zeiss D, oc. 12.

Dimeromyces maculatus Thaxter.

Fig. 232. Well developed female from base of legs. Zeiss D, oc. 2.
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Fig. 234. Base of secondary appendage showing maculation: water im., oc. 4.
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Dimeromyces 1-flagellatus Thaxter.

Fig. 236. Female individual: water im., oc. 4.
Fig. 237. Male and female adherent; less magnified.
Fig. 238. Male: water im., oc. 4.

Dimeromyces kamerunensis Thaxter.

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Fig. 241. Male: water im., oc. 4.

Dimeromyces oscinosomalis Thaxter.

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Fig. 244. Extremity of secondary appendage, showing terminal cell before splitting: water im., oc. 4.
Figs. 245 and 246. Tips of two perithecia seen from different angles: water im., oc. 4.
Fig. 247. Male: water im., oc. 4.

Dimeromyces pedalis Thaxter.

Figs. 248 and 249. Posterior and lateral views of female, the latter with adherent male.
Fig. 250. Male individual: water im., oc. 4.

DESCRIPTION OF PLATE X.

Dimeromyces annulatus Thaxter.

Fig. 251 and 252. Two mature females seen from opposite sides: water im., oc. 4.
Fig. 253. Young female with unbroken primary appendage at left: water im., oc. 4.
Fig. 254. Male: water im., oc. 4.

Dimeromyces appressus Thaxter.

Figs. 255 and 256. Two females from different points of view, from Trinidad.
Fig. 257. Type of female from Ceylon, seen from a third angle.
Fig. 258. Male, from Trinidad: water im., oc. 4.

Dimeromyces Aphanocephali Thaxter.

Figs. 259 and 260. Two females from opposite sides.
Fig. 261. Male: water im., oc. 4.

Dimeromyces Australasiae Thaxter.

Figs. 262 and 263. Two females seen from opposite sides, the first with male.
Fig. 264. Male with two antheridia: water im., oc. 4.

Dimeromyces Prorei Thaxter.

Figs. 265 and 266. Two females seen from opposite sides.
Fig. 267. Male: water im., oc. 4.

Dimeromyces Anisolabis Thaxter.

Fig. 268. Female Type from Argentina.
Fig. 269. Female on *Euborellia* from the Amazon.
Fig. 270. Male Type from Argentina: water im., oc. 4.
Fig. 271. Female from Wai Ai, Solomon Islands.
Fig. 272. Female from Turuca, Fiji Islands. The lower secondary appendage showing two branches from the basal cell not often found.
Fig. 273. Male from Wai Ai, Solomon Islands: water im., oc. 4.

Dimeromyces Tomari Thaxter.

Figs. 274 to 276. Three females, the first with male attached.
Figs. 277 and 278 Two males: Leitz 1/16 oil im., oc. 4.

Eudimeromyces Chiliotis Thaxter.

Figs. 279 and 280. Two females from opposite sides, the first with male attached.
Fig. 281. Male, showing indications of division in the terminal antheridium: Leitz 1/16 oil im., oc. 4.

Dimeromyces aberrans Thaxter.

Figs. 282 and 283. Two females seen from opposite sides, having two and four perithecia respectively: water im., oc. 2.
Fig. 284. Female and adherent male (cf. fig. 247): water im., oc. 2.
Fig. 285. Male: water im., oc. 4.

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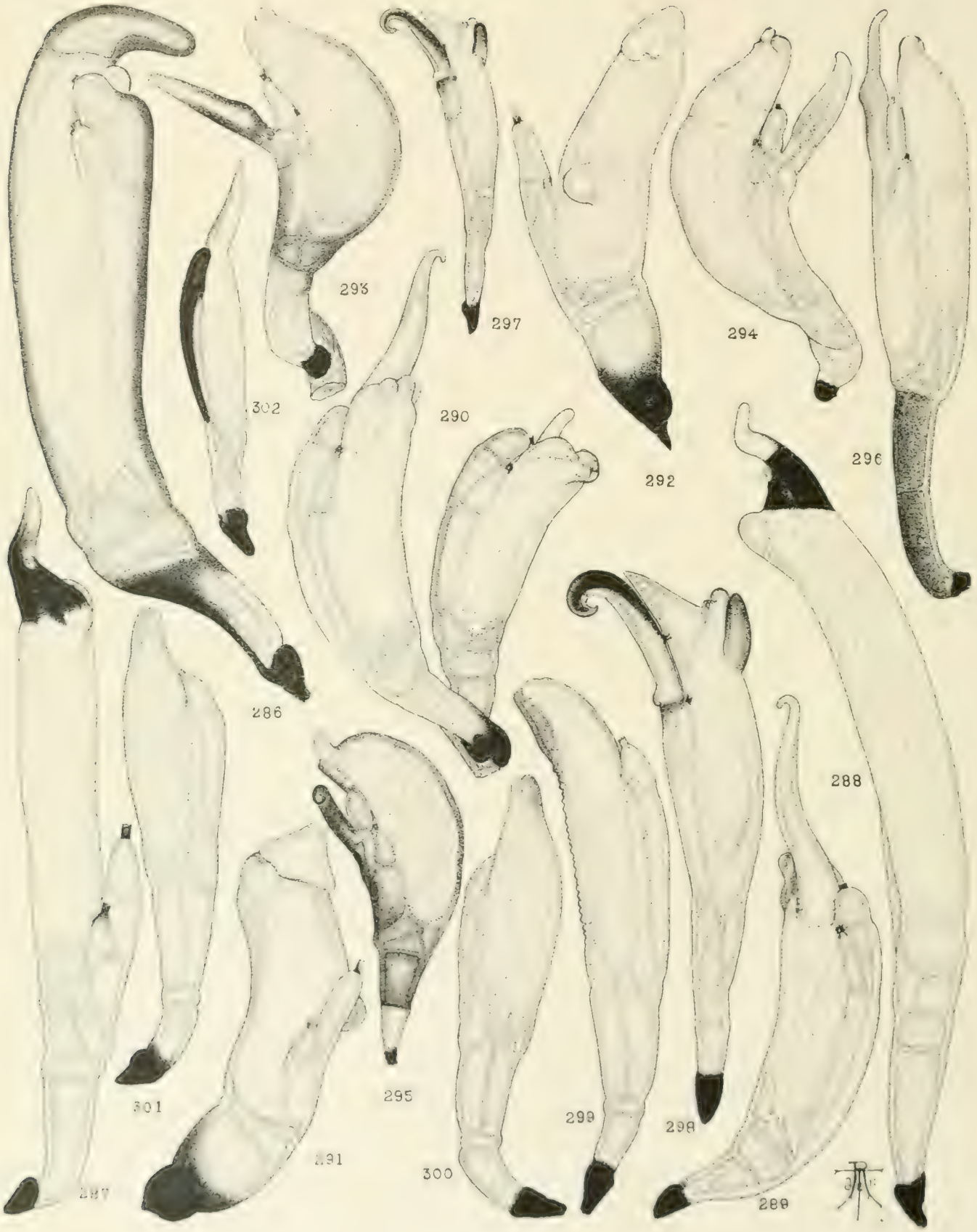
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DESCRIPTION OF PLATE XI.

Chitonomyces chinensis Thaxter.

Fig. 286. Mature individual from left side.

Chitonomyces corniculatus Thaxter.

Fig. 287 and 288. Two individuals seen from the left and edgewise respectively.

Chitonomyces orientalis Thaxter.

Figs. 289 and 290. Three individuals; one from left, two from right.

Chitonomyces aripensis Thaxter.

Figs. 291 and 292. Two mature individuals seen from left and right respectively.

Chitonomyces manubriolatus Thaxter.

Figs. 293 and 294. Two individuals from Trinidad, (Type), and Grenada, B. W. I.
Fig. 295. Variety from China.

Chitonomyces gracilipes Thaxter.

Fig. 296. Unique Type.

Chitonomyces helicoferus Thaxter.

Figs. 297 and 298. Two individuals; the latter enlarged: water im., oc. 4.

Chitonomyces rugosus Thaxter.

Fig. 299. Individual seen from left.

Chitonomyces Australasiae Thaxter.

Figs. 300 and 301. Two individuals seen from right and left.

Chitonomyces prolongatus Thaxter.

Fig. 302. Type from right.

DESCRIPTION OF PLATE XII.

Chitonomyces bicolor Thaxter.

Figs. 303 and 304. Individuals seen from left and right respectively.

Chitonomyces seticolus Thaxter.

Figs. 305 to 307. Three individuals; 306 younger and showing the roughness, obscured in fully matured specimens. In 306 and 307, the ridges on cell *f*, though represented, are actually on the other (right) side and on the margin. In 305, they are shown as they are actually present on the right side.

Chitonomyces japanensis Thaxter.

Figs. 308 and 309. Two individuals seen from right and left respectively.

Chitonomyces melanurus Peyritsch.

Fig. 310. Individual from Japan.

Chitonomyces striatus Thaxter.

Figs. 311 and 312. Two individuals seen from right; the latter enlarged: water im., oc. 4.

Chitonomyces uncinulatus Thaxter.

Figs. 313 and 314. Individuals seen from left and right respectively.

Chitonomyces oedipus Thaxter.

Figs. 315 and 316. Two individuals seen from right and left respectively.

Chitonomyces Grenadae Thaxter.

Figs. 317 to 319. Three individuals seen from right, edgewise, and left respectively.

Chitonomyces cerviculatus Thaxter.

Figs. 320 and 321. Two individuals seen from right and left respectively.

Chitonomyces introversus Thaxter.

Figs. 322 and 323. Two individuals seen from right and left respectively.

Chitonomyces longirostratus Thaxter.

Fig. 324. Mature individual seen partly edgewise.
Fig. 325. Young individual showing cell-arrangement.

Chitonomyces Thaxteri Spegazzini.

Figs. 326 and 327. Smaller and larger individual, from left and right.

Chitonomyces excavatus Thaxter.

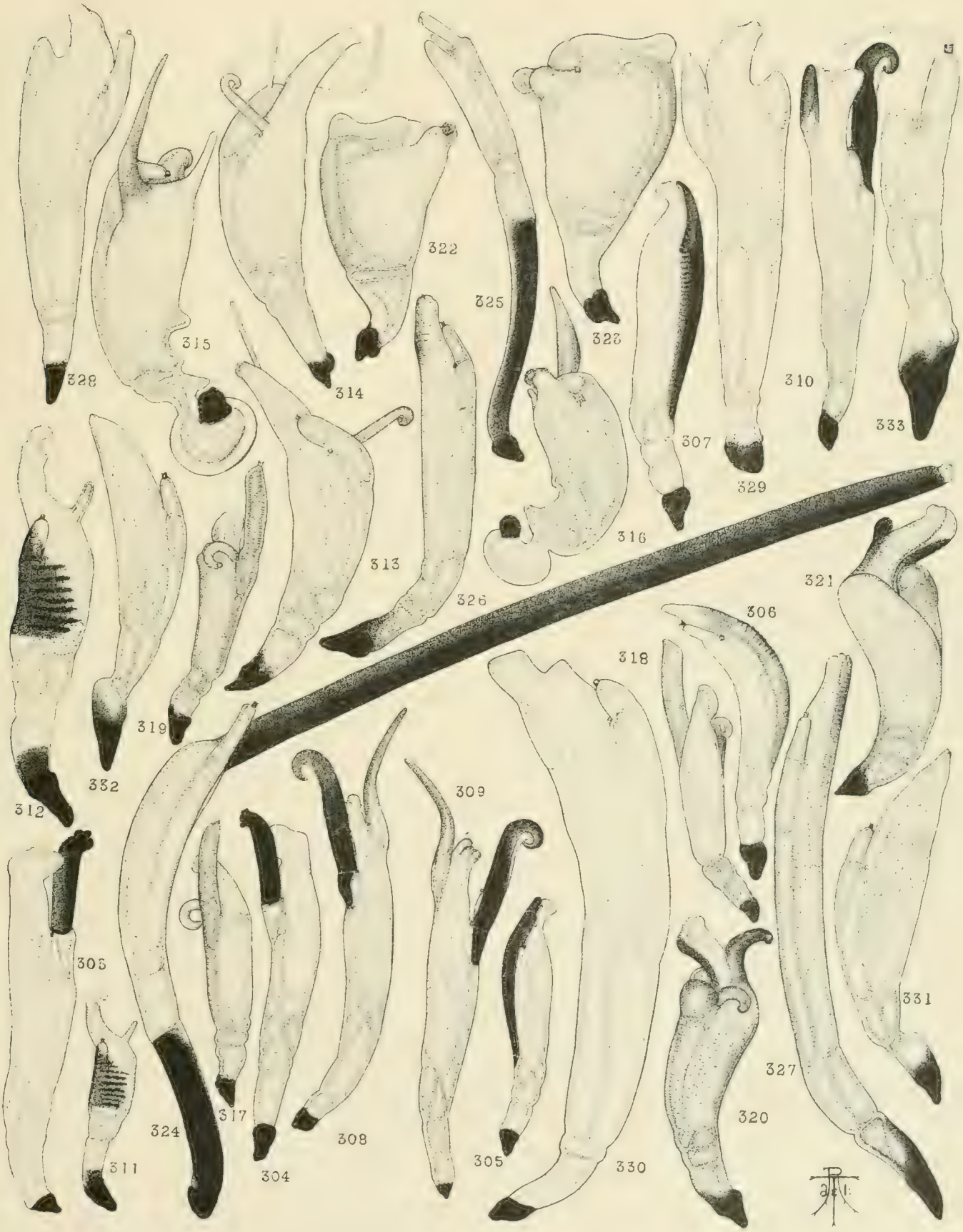
Figs. 328 and 329. Two individuals seen from left and right respectively

Chitonomyces incisus Thaxter.

Fig. 330. Type seen from left.

Chitonomyces inflatus Thaxter.

Figs. 331 and 332. Mature individuals seen from right and left respectively
Fig. 333. Young individual, showing position of carpogenic cell.



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